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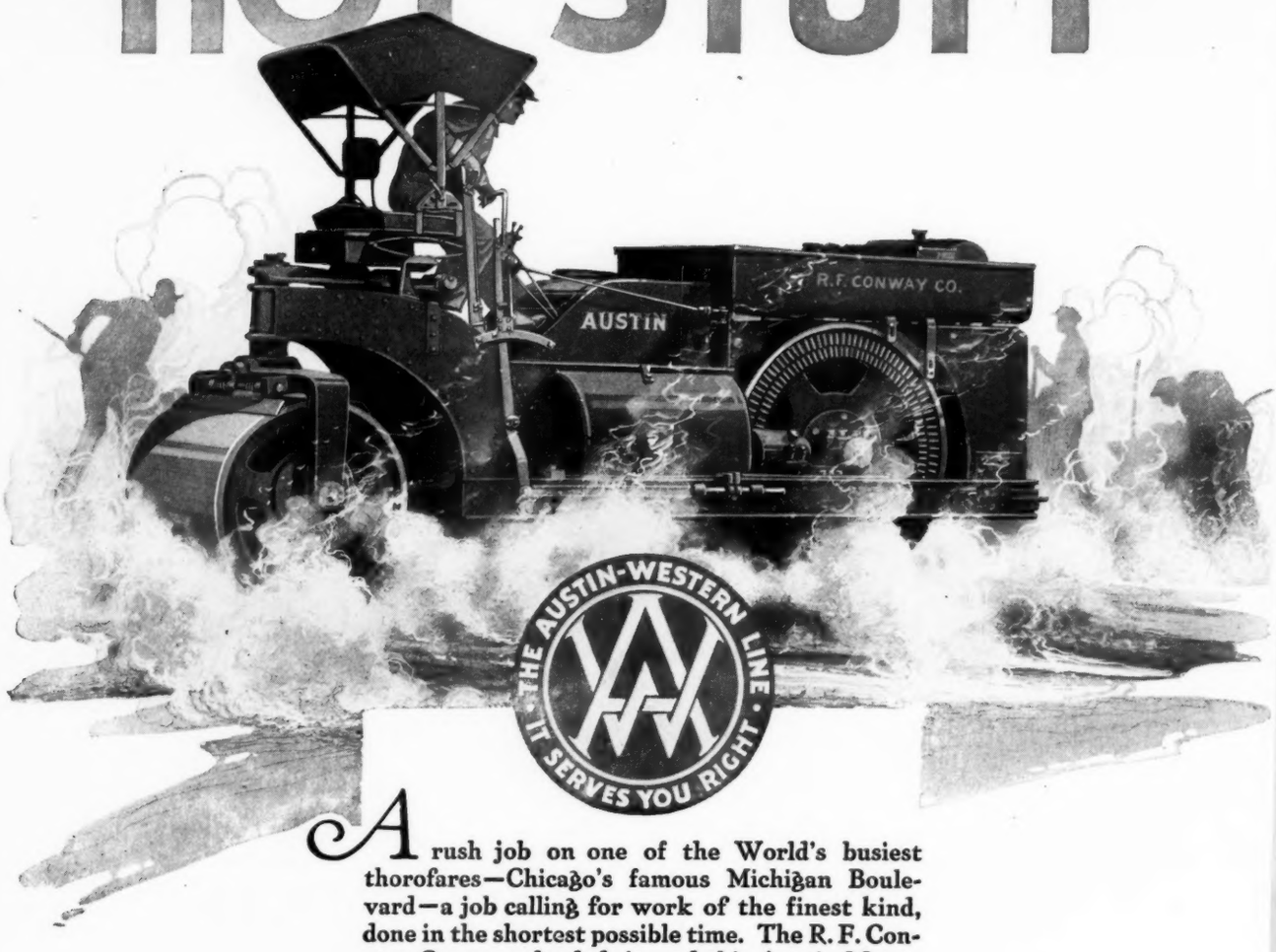

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WHY TAKE LESS IN A TANDEM?

THE AUSTIN-WESTERN ROAD MACHINERY CO.

CHICAGO

VOL. 55 NO. 1

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PUBLIC WORKS.

CITY COUNTY STATE

A Combination of "MUNICIPAL JOURNAL" and "CONTRACTING"

Vol. 55 January, 1924 No. 1

Nashville–Springhope Highway

Fifteen miles of sixteen-foot concrete surface laid on existing clay-gravel road in eight months. Hand work reduced to a minimum and close analysis of weekly reports to secure maximum efficiency.

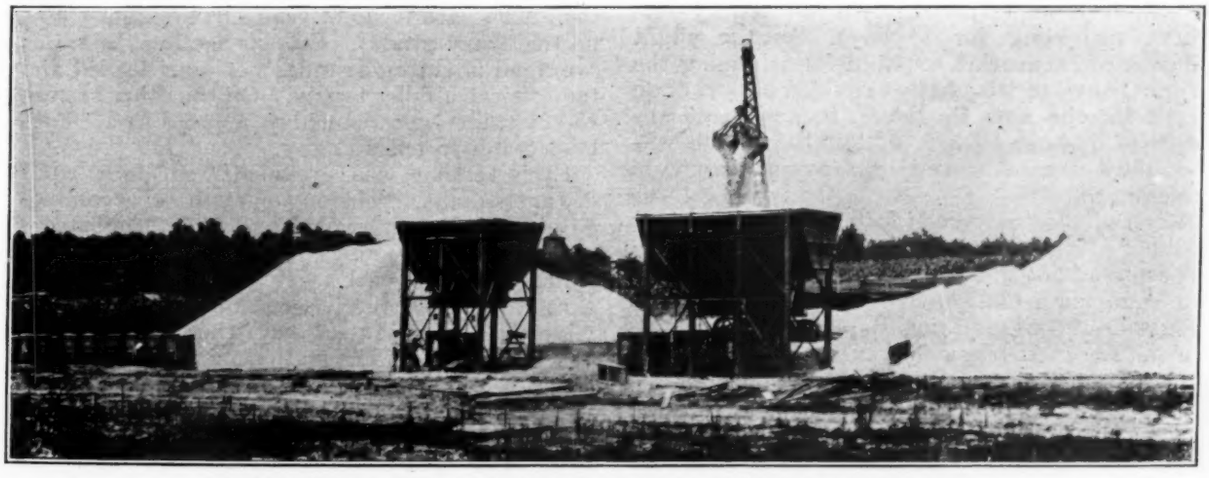
By Frank W. Skinner

Route 90, from Raleigh to Columbia, North Carolina, forms part of a 400-mile trunk line that traverses that state from east to west and is now being improved by the State Highway Department, Frank Page, chairman of the Commission. The aim is to eventually make it a hard-surfaced thoroughfare from end to end. The contract for the just completed section, 15 miles long, from Nashville to Springhope, was let for a contract price of $409,592.40 to the Public Service Production Company of Newark, New Jersey, N. A. Carle, vice-president and general manager, T. J. Wasser, civil engineer, which commenced work on the 15th of June, last and expects to have it completed by the 18th of January.

The original location of the old highway was nearly everywhere followed and passes through a rather thinly settled agricultural section of rolling country. It has several long 5% grades with a number of curves, four of them requiring super-elevation. It was serving a large through automobile traffic and the local farm-wagon traffic, all of which was detoured to convenient parallel roads maintained by the State Highway Department so that the new construction was not impeded by any traffic restriction.

The concrete surface has a 7-foot earth shoulder on each side and is 16 feet wide with a thickness of 6-8-6 inches, averaging 7⅓ inches and requiring 36.2 cubic yards of concrete per 100 lineal feet of roadway. The contract includes no bridges or other important structures. Its principal quantities are about 15,500 yards of common (earth) excavation, 5,000 yards of borrow, 138,700 square yards of concrete pavement requiring 36.2 cubic yards concrete per 100 lineal feet, 34,000 tons of crushed granite, 17,000 tons of sand and 43,000 barrels of Atlas Portland cement.

Expansion is provided for only in the construction joints, usually several hundred feet apart, which are made at the end of each day's work. These are simple butt joints, each of them bonded with 9 horizontal steel dowels projecting 2 feet beyond each side of the joint and greased so as to prevent adhesion of the concrete.



STOCK PILES, BINS, LOCOMOTIVE CRANE AND BATCH BOX TRAINS.

ORGANIZATION

The work was designed and executed under the direction of State Highway Engineer Charles M. Upham and supervised by resident engineer G. C. Walker, aided by a survey party and six inspectors.

The contractor at first proposed to execute the work in two nearly equal sections, each of them equipped with a full-length industrial service track. Conditions, however, eventually made it desirable to make a third section 3 miles long, provided with motor trucks instead of industrial track service, and to operate the remainder of the contract in two sections, 5 miles and 7 miles long respectively, each served by an industrial track. The method of distribution of cement and aggregate and the operation and equipment for each section were substantially alike, and their organizations the same, each having a separate superintendent reporting to G. E. McNutt, district superintendent, who generally visited the work two or three times each week.

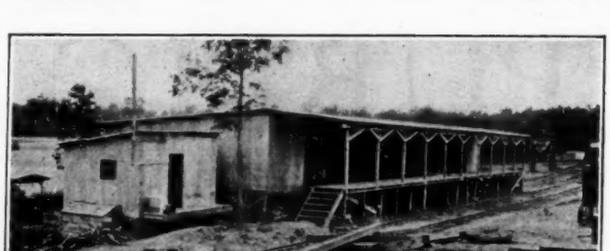
GRADING AND CONCRETING

The existing road having a good clay-gravel surface on well-drained sand topsoil, it was first scarified by a Buffalo-Springfield 10-ton roller and the material removed to a maximum depth of 6 or 8 inches by Western Wheeled Scrapers and Fresno's, hauled by three 5-ton tractors. Where necessary, a No. 7 or No. 8 Adams road-grader (of which three were provided) was also used, and the subgrade was finished with a sub-grader. Blaw Knox 6-inch "dreadnaught" steel forms were set about 700 feet in advance of the concrete mixer. The mixers were fed by means of batch boxes on two sections and batch trucks on the third. The surface of the concrete was finished by an Ord surfacer. Little hand-finishing was required, and the fresh concrete surface was immediately protected by a covering of 60-inch-wide transverse strips of burlap, laid within two hours of the concreting and kept wet until the next day, when they were replaced with ponding. When the grade was too heavy for ponding or when sufficient clay for the dams was not readily available, the curing was effected by 8 inches of salt hay, kept thoroughly saturated by frequent sprinkling for 14 days. As the slight amount of excavation required for trimming the original surface frequently provided only enough earth for the new shoulders, it was necessary to furnish about 50 tons of salt hay which was generally used over and over again, about six times in all.

Each of the three sections required about 100 gallons of water per cubic yard for sprinkling, concrete mixing and other purposes. This water was pumped from convenient creeks or ponds alongside through a 2-inch pipe at a pump pressure of about 150 pounds.

HANDLING MATERIAL

Cement in bags, a high quality of sand, and run-of-crusher granite of ¼-inch to 2½-inch diameter with tailings rejected, were delivered by railroad cars to three storage stations, one located near the central point of each contract section, and there unloaded, stored and delivered for transportation to the concrete mixers, which, in general, worked toward the stations. At each station there was installed a 5-ton Blaw Knox suspension bin type batcher plant for sand and gravel and a locomotive crane with caterpillar traction that used a clamshell bucket for unloading the sand and gravel aggregates into the storage bins; or, when necessary, onto storage piles, from which it later reclaimed the aggregate to the storage bins or to the batch-boxes. There was also provided a weatherproof cement shed with elevated floor and a capacity of about 2,000 bags of cement and a 14x30x8-foot or a 14x15x8-foot Blaw Knox steel handy house.



THREE-THOUSAND-BAG CEMENT SHED.

There were used for unloading and handling aggregate at the receiving stations three locomotive cranes with caterpillar tractions and 40-foot booms equipped with two Blawknox and one Hayward ¾-yard clamshell buckets. On the different sections there were installed altogether one 21-E Koehring, one No. 1-S T. L. Smith, and one No. 107-S Koehring concrete mixers.

Aggregate and cement were transported from the station to the concrete mixer on the 5 and 7-mile long sections in 192 batch-boxes carried in pairs on 96 small flat cars, hauled by 8 Whitcomb locomotives, besides which two 3-ton Plymouth locomotives were kept at the station for utility and switching operations.

On one of the sections the grades were much steeper than on the other section and limited the four trains to 8 cars each, drawn by one locomotive, which was found more satisfactory than using two locomotives to haul longer trains up the heavy grades. On this section the trains averaged about eight miles per hour loaded and ten to twelve miles empty. On the other section 15-car trains were hauled at a speed of 12 miles loaded and 15 miles empty.

Each section was provided with four equidistant sidings, each long enough to accommodate a maximum train-length. On the steep-grade section 7 miles long, the three loaded trains entered each siding successively and waited there for the passage of the empty train which had the right-of-way, thus avoiding any delays at the loading station or mixer. On the other section, where the grades were lighter, the rule was reversed, the empty train entering and backing out of all of the successive sidings while the loaded cars had right-of-way. As operated, both systems gave equally good re-

sults, and both eliminated all switch tenders and the possibility of collision.

On the 3-mile section of the contract, the industrial railway and cars were replaced by seven 2-ton dump-body automobile trucks. These trucks were provided with swinging partitions, enabling them to dump successive batches into the loading skip of the concrete mixer, thus eliminating the service there of an unloading crane. The use of trucks instead of industrial railway service on this section was rather a matter of convenience for the contractor's organization and equipment than because of any special preference or desire for comparison.

On all of the sections both aggregate and cement, when practicable, were unloaded from the cars directly into batch-boxes and trucks without passing through storage. The industrial tracks passed between the railroad sidings and the cement shed so that they might be loaded with equal readiness from either side and the cement bags were easily delivered from the cars to the shed over a light bridge spanning the narrow gauge track. The empty bags were cleaned and packed by a shaker and baler installed at each station. A large reserve of cement and aggregate was maintained at each

TRAIN OF BATCH BOXES ON SIDING.

station; and the storage bins, from which the batch-boxes and trucks were very rapidly loaded by gravity, were kept filled by the locomotive cranes that were almost continually occupied unloading the cars or in reclaiming from the large storage piles.

CONSTRUCTION WORK

The elevation and finish of the subgrade were under constant supervision of the inspector, who also very carefully watched the proportioning of the 1:2:4 concrete, verified the minimum time of 1½ minutes of actual mixing, regulated the amount of water so that a uniform and satisfactory consistency was attained, and occasionally made slump tests and took samples for laboratory tests that were eventually supplemented by compression tests of shot-drill cores from the finished pavement.

Allowing 1½ minutes for mixing the concrete and ½ minute for charging and discharging it, the theoretical maximum output of one machine in one 10-hour shift was about 700 lineal feet of roadway. When the daily report showed that this amount had been considerably exceeded, an immediate investigation was made by the State Highway Engineers Department. It was learned that the extra product had been made possible by several speeding-up details, the principal one being the simultaneous performance of three different operations, namely, charging and discharging the mixer and moving the machine forward. As soon as the mixer was well started to discharge, the charging hopper was elevated, and it commenced to deliver to the mixing drum while the latter was returning to normal position. In the meantime the machine advanced on its caterpillar traction to the new position ready to deposit the next bucket of concrete farther ahead on the road. A few seconds were also saved by placing the unloading derrick on the same side of the machine as the industrial track so that it and the batch-boxes could be watched by the operator without moving from his regular position.

The average number of men employed was about 180, who were equally divided among the three sections, except that the industrial track sections each required five more men than the section equipped with trucks. The best record for one mixer for one day was 787 lineal feet, equal to 285 cubic yards of concrete, in 11 hours. During the week ending December 15th there were laid on the three sections a total of 8,271 lineal feet of pavement with a total force of about 185 men working five 10-hour days. This is believed to be the state record for progress, while the estimates of $79,000 and $77,000 allowed to the contractor for the months of October and November, respectively, are believed to be the largest monthly estimates ever paid on one project by the State Highway Department of North Carolina.

MAINTAINING EFFICIENCY

The division of the work into three separate sections under a complete individual organization greatly promoted a spirit of pride and emulation between the three working parties and furnished an incentive for each of them to achieve the best record, which, as conditions were substantially alike for all of them, varied daily, leaving in doubt until the last day which party would first complete its section, an achievement for which the promised reward was its transfer

ROAD FINISHER IN OPERATION.
Construction track on the left; completed road in the background.

to a desirable new contract soon to be undertaken on the Tarboro Road.

On the wall of the contractor's office in Raleigh there was conspicuously displayed a diagram having a separate long, horizontal line for each of the three divisions of Project 163. As the work progressed, the advance for each week was marked off and dated, and in each space was recorded the number of square yards and lineal feet of concrete laid. Daily there were placed on the line colored pins permanently set to show the condition of the work from the beginning; red indicated daily progress, pink indicated insufficient material, green indicated no work, (including Sundays, holidays and rain), black indicated weekly progress and yellow indicated monthly progress. The positions of these pins instantly showed by inspection the comparative state of the work on each section, the amount accomplished and the proportion still remaining to be executed.

A statement of the progress of each section was sent every week to the superintendent of each section, and the superintendents frequently visited each other's jobs for the purpose of observing progress and conditions, noting development and improvements and adopting any features that might be beneficial for their own work. The result was very beneficial to the morale of all of the employees and, undoubtedly, tended to accelerate the work, improved its quality and reduced its cost.

The division of the work into three large adjacent sections, all simultaneously engaged on exactly the same kind of work under substantially uniform conditions, enabled the contractor to make comparative observations on the operations of standard machines of different types doing the same work. The installation included in some cases machines of different makes for doing the same work in the different sections, and as there were only three sections, the use of two machines of one make and one machine of another make, where only one machine was required in each section, was not significant of the value or appreciation of the particular machine.

THE FORCE EMPLOYED

The regular force of about 180 men, working one 10-hour shift daily, was composed of colored laborers and white mechanics and foremen, and was carefully organized so that each man was trained for his own specific duties, which were performed promptly and without loss of his own time or obstruction to others. The idle and inefficient were gradually eliminated and excellent cooperation and uniform results were obtained.

On each section there were required one superintendent, one concrete foreman, one fine grade foreman, one rough grade foreman, one plant foreman, one construction clerk, one timekeeper, one master mechanic, one crane operator at the receiving station, two men on industrial cars to spot the locomotive crane buckets and clean up the cars, six men loading industrial cars with aggregate and cement who also unloaded and stored the cement and cleaned and baled the empty bags, four locomotive drivers, four locomotive brakemen, three trackmen, one mixer operator, one mixer derrick operator, two men dumping batch-boxes in charging skip, three men spreading concrete behind the mixer, one operator for finishing machine, one tender for finishing machine, one operator for belt machine, one man edging, four men ponding or spreading and sprinkling the hay to cure the concrete, one pump operator, two form setters, ten men transferring forms and doing the fine grading, one tractor operator, one roller operator, one road machine operator, two drivers for wheeled scraper teams, three water boys and one watchman.

On the short section having motor truck hauling, the force was the same except that there were no locomotive drivers or brakemen, no mixing machine derrick operator and only four men were required to load the trucks; while there were required in addition seven truck drivers and one operator for the truck turntable. Two men were also required to dump cement into the trucks while the latter were on the turntable near the mixer, thus saving an appreciable amount of time at this point. Another time-saver which effected a visible increase in the daily progress was the removal, in good weather, of the covers over the cement compartments in the batch-boxes, thus eliminating the necessity of taking them off and gathering them up again as the batch-boxes approached and left the mixer.

COST DATA

The construction clerk and the timekeeper together gathered classified cost data, from which there were prepared for each section of the contract daily statements of the cost per lineal foot of fine work; per square yard of fine grading; per square yard of concrete paving and finishing; per square yard of concrete curing; cubic yard of common excavation, and square yard of shoulders. These figures, posted daily, were immediately analyzed by the district superintendent and the office manager, who maintained constant watch for any variation in cost.

The daily field report from each section superintendent showed the number of days allowed for the execution of the work, the days already worked and the days remaining, and contained blanks for recording the dates, the number of batches of concrete poured, the average haul, the weather, both morning and afternoon, and gave each contract item such as excavating, fine grading, concreting, curing, etc., the number of lineal feet, the progress from station to station, daily position, amount finished to date, the unit of computation (cubic yard, square yard, lineal foot, etc.), the cost per unit of labor, material, equipment and miscellaneous. These gave the total cost on this day and the average cost to date. There was also a stock record for the regular items of cement, sand, stone, rein-

forcement steel, dowels, gasoline, lubricating oils, grease and miscellaneous supplies, with columns for the amount received, the amount used and the amount on hand. Blanks were also provided for the description of delays, accidents and remarks.

This report served as a perpetual daily inventory of major materials, and if any items were found to be in excess of the estimated cost, they were immediately investigated. The sum of the cost items multiplied by the day's yardage gave the total expense for the day and the sum of the costs per unit to date multiplied by the corresponding quantities quickly gave the total cost of the job to date, which, in November, agreed with the engineer's estimate and ordered changes within 1½%.

When this contract was about 40% completed, all of the initial outlay for buildings, for the installation of plant and equipment and the operating costs for plant rental, labor, materials, overhead, fixed charges, etc., were added up and the sum was divided by the amount of the concrete then laid, giving a temporary unit cost per square yard. This cost was thenceforward successively computed for every day's cumulative progress, thus showing a gradual decrease of unit costs.

When these decreased costs became less than the unit costs of the estimate, the contract was obviously beginning to be profitable. By watching this decreasing scale of costs, the superintendents of the different sections were in touch with the economic conditions of the work and were stimulated to reduce the costs and secure better and better results.

Clifford Older Resigns

Clifford Older, chief engineer of the Illinois State Highway Department, has resigned that position, effective as soon after February 1 as his successor is appointed.

He will thereafter devote all his time to the Consoer Engineering Co., of Chicago, of which he has been president for some time past, the firm name being changed to Consoer, Older & Quinlan.

Mr Older has been connected with the Highway Department for more than 17 years, first as bridge engineer, and as chief engineer since 1917.

University of Tennessee Course in Highway Work

The University of Tennessee, in co-operation with the State Department of Highways, will establish a short course in highway engineering, this year's course having been set for January 7 to February 2. There will really be two courses, one for elementary work in surveying, drawing and highway construction, for those without previous engineering training; the other in testing materials and in highway administration and finance, for those who have had considerable experience in highway work. No entrance examinations are required, but any one can take the course on payment of a nominal fee of $10.

Civil Service Examinations

Civil service examinations for positions in New York State, open to citizens of other states as well, will be held on January 19th. The positions of interest to engineers are as follows: Junior assistant to the Transit Commission of New York City, salary $1,500 to $2,100; junior assistant engineer to the State Highway Department, $1,620 to $1,860; junior draftsman to the Transit Commission, $1,500 to $2,100.

United States civil service examinations will be held on February 7th for transitmen in the Forest Service at entrance salaries ranging from $120 to $170 a month; and for junior topographical engineer with the Geological Survey at entrance salaries of $2,100 to $2,640 a year.

Preparators (to make mechanical models) for National Museum, $95 a month. Examination February 19.

Laboratory assistants for the Bureau of Standards, U. S. Department of Commerce, salary $1240 and $1140 a year. Examinations, March 5.

Junior Engineer, Junior Physicist and Junior Technologist, for the Bureau of Standards, salaries $1440 to $1740 a year. Examinations, March 5.

Junior Aids for the Bureau of Standards, $780 to $1080 a year. Examination March 5.

The above may be of interest to some one. But we wonder why the wealthiest government in the world pays men with technical ability and education $2.50 to $5.60 a day—about half what the building trades pay for laborers and mechanics.

City Engineers for Camden

Camden, N. J., has divided the position and functions of city engineer, J. C. Remington, who was appointed as city engineer, being now known as engineer of construction, while an engineer of maintenance will take up the functions indicated by that title, Thos. J. Daly having been appointed to that position.

Road Construction in the South

It may surprise many, especially those living in the North, to learn that the greatest interest in good roads is now to be found in the South, and not only interest but also definite programs for expenditure. This is indicated by a list of the bond issues authorized during the year ending Aug. 1st, 1923, as compiled by J. E. Pennybacker, secretary of the Asphalt Association.

This list shows that Virginia leads all the other states in contemplated improvements with Tennessee second and Texas third. If the amount actually authorized be made the basis of arrangement, Pennsylvania leads with Illinois second, and Florida third.

The bond issues under consideration but not yet authorized included $79,763,000 for Virginia,

$78,807,500 for Tennessee, $72,703,000 for Texas, $61,125,000 for Georgia, $55,255,000 for Kentucky, $10,350,000 for Florida, $4,503,000 for Louisiana, $2,045,000 for Mississippi, $5,282,990 for Missouri, $3,525,000 for North Carolina, $17,825,000 for Oklahoma, $7,733,000 for South Carolina, $5,419,400 for West Virginia, $350,000 for Alabama.

Bond issues authorized during the year, exclusive of federal aid, included $6,605,000 for Alabama, $35,493,000 for Florida, $1,005,000 for Georgia, $5,987,000 for Kentucky, $9,813,100 for Louisiana, $5,325,000 for Mississippi, $15,634,999 for Missouri, $25,540,000 for North Carolina, $4,915,000 for Oklahoma, $5,611,000 for South Carolina, $984,000 for Tennessee, $18,406,500 for Texas, $4,096,493 for Virginia and $16,197,665 for West Virginia. New Mexico was the only southern state in which practically nothing was either authorized or contemplated.

Denver's Paving Program

Denver has prepared a program for paving its streets that is estimated to involve an expenditure of $4,000,000; to be spread over several years, however.

Of the 900 miles of streets in the city, 75 miles are paved, 241 miles are surfaced, while 584 miles are as yet only dirt streets. There is approximately the same number of miles of alleys, of which 106 miles are paved. Alley paving is encouraged and has been progressing at the rate of about 25 miles a year since 1920.

The surfacing on the non-paved streets consists of washed sand and gravel with no binder. This material has been put on year after year for the last twenty years, pulverizing and blowing away as dust at about the same rate as it is applied.

One line of street three miles long is found to be costing $5,300 a year per mile, of which $2,000 is maintenance, $1,300 is sprinking and $2,000 is resurfacing. It is estimated that the cost of paving would be approximately $40,000 per mile. Another street paved 24 years ago has been maintained and washed at an average cost of $78 per mile per year and it was estimated that it has suffered a depreciation of only 30%. On the basis of these and other figures, the Mayor strongly urges that durable pavements be constructed on the main traffic streets as rapidly as possible.

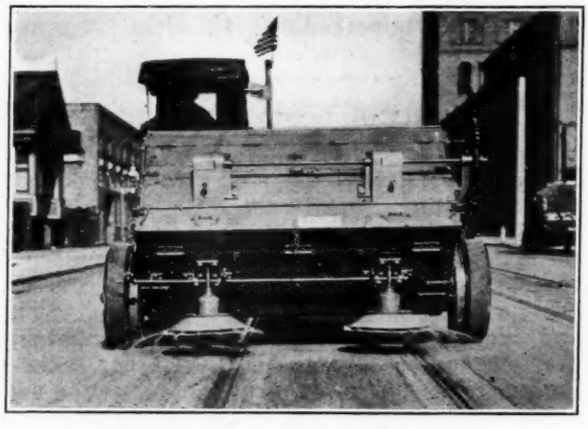
Effect of Bituminous Roads on Fish

A few years ago English authorities were more or less disturbed by the idea that the use of oil or other bituminous material on roads might be injurious to fish life in streams or ponds past which the road was carried and into which the washings from it might flow. For a year or two we have not noticed anything in the technical press of England on the subject, and presumably the final statement has recently been made in a report by the Ministry of Agriculture and Fisheries of that country. They made two tests, one by placing two-year-old brown trout in a small pond into which the drainage from a bituminous road was turned, and the trout were found to be unharmed after 19 weeks. The other test was made by placing some pulverized bituminous material from a bituminous road in a receptacle full of water and placing in it some young perch and roach, and these young fish also appeared to be unharmed after spending three hours in this water. The officials, on the basis of these tests and presumably of other investigations, reached the opinion that no appreciable toxic effect would be produced on fish by drainage from roads that had been treated with either hard or soft bitumen.

Asphalt Macadam in Nevada

An asphalt macadam pavement, apparently this year on the Reno-Purdy highway at a cost this year by the Reno-Purdy highway at a cost very much lower than that of concrete. The State Highway Department reported recently that some motorists expressed great satisfaction with this type of roadway while others were doubtful of its durability. The Department advances the opinion that the adverse criticisms are largely due to the fact that the pavement was made only 12 feet wide, with the idea that dirt shoulders could be used for the passing of vehicles. The road, however, was immediately used by everyone within riding distance because of its novelty, with the result that the soft shoulders gave way and the edge of the pavement ravelled out. It is believed, however, that by rebuilding and maintaining gravel shoulders the ravelling could be prevented.

It was stated that this 16 miles of road cost approximately one-quarter of a million dollars less than a concrete road of equal width and thickness would have cost and it believes that it will stand up in excellent shape under the traffic it will be called to carry. One or two spots have shown some weakness, but these are because of the need for draining the subsoil, and this is now being remedied. The cost did not greatly exceed that of a good gravel road and "the riding qualities are so superior to a gravel road that there can be no comparison."



SAND SPREADER IN SAN FRANCISCO

Sanding Oily Streets

In the issue of "Municipal Journal" for October 26, 1918, there was described an apparatus used in San Francisco for spreading sand on the streets where oil and grease had been dropped by automobile traffic. After five years of the use of this spreader, Peter Owens, superintendent of the San Francisco Street Cleaning Department, states that the streets of the city are more free from oil and grease than those of any other he knows of, which condition is very helpful in preventing automobile accidents. At present the city is using a power-driven street sweeper which Mr. Owens has equipped with two centrifugal sand spreaders which spread the sand to a width of from 12 to 20 feet. The machine can cover fifty city blocks in two hours. The practice is to spread the sand one day and wash it off the next, after which washing another film of sand is spread. The city is now equipping a motor truck with a similar spreading apparatus.

Georgia's State Highways

Department constructs and maintains more than fifty-six hundred miles of roads, mostly sand-clay, with no state appropriation but only motor license fees and gasoline tax as sources of income, counties furnishing a large part of the funds.

Georgia is at present, necessarily and wisely (in the opinion of the Bureau of Public Roads), essentially a sand-clay road state. Last July, of its 22,000 miles of surfaced roads, 13,800 miles were sand-clay and 3,350 were gravel, while only 736 miles had been surfaced with bituminous materials or cement concrete.

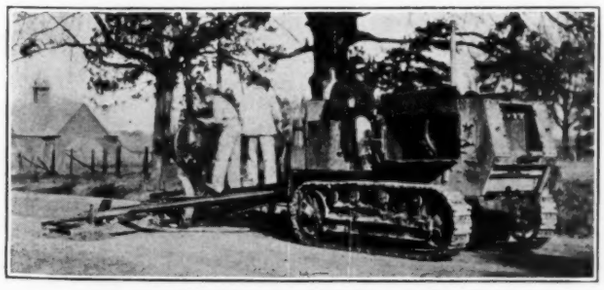
The total mileage of roads in the state is 80,892, of which 48,000 is unimproved and 28,000 is graded and drained but not surfaced. The state system is 7% of this, or 5,662 miles. Of this, about 240 miles is completed hard surface and 1,200 miles has been improved in various degrees, from grading and permanent drainage structures to gravel or chert surfaces, in addition to about 2,000 miles that had been materially improved before the department was organized in 1919. There is also approximately 725 miles of the state system now under construction.

There have been completed to date road and bridge projects to the value of approximately $18,000,000, while there are under construction projects totaling $8,500,000 about 68% completed.

Although the State Highway Department is charged with the construction and maintenance of 5,600 miles of road, the funds therefor to consist of money appropriated by the legislature and that obtained from other sources, so far no appropriations have been made by the state for this purpose and the only revenue available to the department has been the motor vehicle license fees; and so lax has been the enforcement

A TWO-TON MAINTAINER DRAGGING A ROAD.

TYPICAL SURFACE CONDITION AFTER USE OF LIGHT EQUIPMENT.



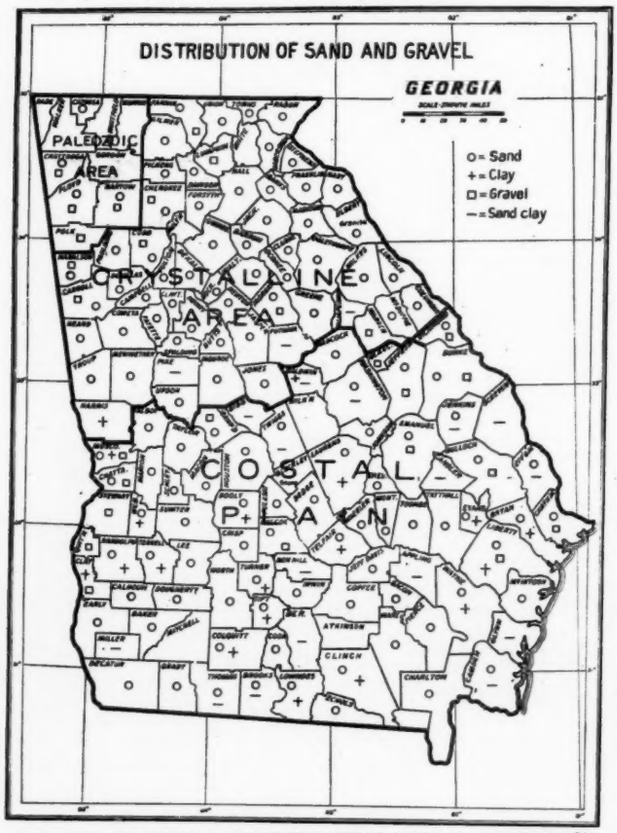
FIVE-TON ROAD PLANER SMOOTHING ROAD SURFACE

TYPICAL SURFACE AFTER USE OF HEAVY EQUIPMENT.

of the law that fully a fourth of the vehicles in the state have paid no fees. Last year the fees turned over to the department totaled only about two million dollars. Now, however, a 2-cent gasoline tax is in force from which considerable financial aid is anticipated.

In spite of the small fund that it has available, the department has effected an enormous improvement in the roads of the state, chiefly by inducing the counties to appropriate, for construction under its supervision, funds sufficient to match the Federal Aid allotment, which allotment has amounted to $12,466,087.

Although it has been so hampered in this and other ways, the department was accused of inefficiency and other faults and in March, 1923, asked for an examination by the Bureau of Public Roads, and in May that Bureau thoroughly investigated the activities of the Board, rendering its report in July. This report approved the general use of sand-clay roads; stated that the organization of the department was suitable and its administration well conducted, considering the handicaps. Its only criticism was that the road building equipment should be more adequately protected from the weather. It gave, as one of the outstanding facts revealed, that the department should, as early as possible, be provided by the legislature with funds sufficient to enable it to comply wiht the duties imposed upon it by that body, and be permitted to use these in accordance with a state-wide plan of highway improvement. The counties should no longer be asked to pay the state's road bills when they "seriously need all the money they have, for use on roads lying off the state system."



MAP OF GEORGIA, SHOWING GEOLOGICAL DIVISIONS AND DISTRIBUTION OF SAND AND GRAVEL.

SAND-CLAY ROADS

In the report referred to, the opinion was expressed that the construction of sand-clay roads in Georgia "permits the use of local material, is comparatively cheap to construct and, where traffic needs are moderate, as is the case in the larger portion of the state, this type is easily and economically maintained. Furthermore, as traffic increases and a higher type becomes necessary, the sand-clay will serve admirably as a foundation and the higher type can be constructed upon it without material loss in the original investment." Traffic counts taken by bureau and board in cooperation "indicate that the traffic now coming upon some of the roads requires their early reinforcement, or reconstruction as to type."

Reference is made in the above to local material, and this indicates the importance of the knowledge of the distribution throughout the state of the various materials available for road purposes. Geologically Georgia may be separated into three divisions referred to as the paleozoic, the crystalline and the coastal plain. These are shown on the accompanying map.

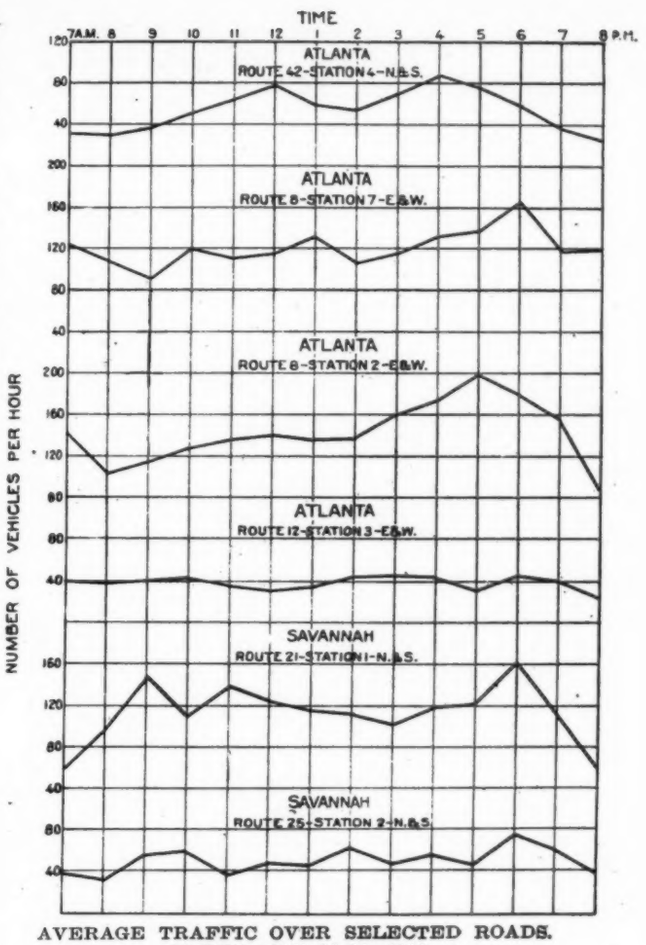
In the paleozoic, in the extreme northwestern corner of the state, are found limestone, shales, slates and sandstones, which have been somewhat altered along the eastern margin. Sand and gravel also occur throughout this area. In the crystalline area are found schists, gneisses and some granite quartzite, and dikes of diabase or similar basic rocks. In this area are a number of quarries supplying crushed stone for concrete and also pits furnishing sand and gravel. The coastal plain occupies the remainder of the state and contains layer upon layer of sedimentary deposits ranging from sand to marl. Sands, clays and gravels, with the first two predominating, are found throughout this area. The use of sand-clay roads is, therefore, naturally suggested for this section of the state. The traffic counts previously referred to show that on most of the Georgia roads traffic is relatively light and that on these the sand-clay type of construction can be used wisely.

The cost of sand-clay roads in Georgia is from 40 to 50 cents a cubic yard compacted in place, or $1,200 to $1,500 a mile. It is estimated that under present conditions and on roads of considerable traffic the surface must be replaced about once every four years at a cost of perhaps $2,000 a mile if done separately and not at the same time as grading and other work. There is considerable loss of surface material from these roads, which is washed off during heavy rainstorms and blown off in the form of dust during dry weather. The exact amount of this loss depends more or less on the amount of traffic, but usually varies between ½-inch per year as a minimum on light-traffic roads to 2 inches or more under heavy traffic. The material so removed should be replaced, and so far un-

fortunately the inadequacy of the maintenance funds at the disposal of the State Highway Department has not made this generally possible. It is planned to begin, in 1924, placing a permanent wearing course on several of the top-soil and gravel roads.

It is believed to be the consensus of opinion of the state highway departments of the country that sand-clay and gravel construction is suitable for traffic up to 500 or even 750 vehicles a day. Georgia's experience indicates that if roads now surfaced with sand-clay and carrying more than 500 vehicles a day be reinforced with about 2 inches of screenings of stone of good wearing qualities spread over the surface uniformly and rolled once thoroughly and thereafter allowed to work into the road surface with the traffic, a road so reinforced and carefully maintained will carry a traffic up to 850 vehicles a day unless there are too many heavily-loaded trucks. It will at least do this for the time needed to ascertain, through the research work now being done, at what traffic load a change in type is economically desirable. It is considered that where the traffic during a 14-hour day exceeds 850 vehicles, of which approximately 10% are trucks, such roads should undoubtedly be reconstructed as soon as possible.

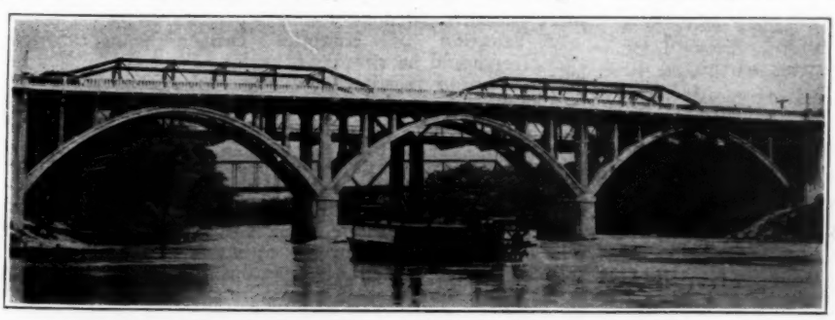
It was thought by the Bureau that the Department should pay special attention to experiments looking to a further development of the sand-clay road, and a special study of this type of road is being conducted, largely with the aid of Professor C. M. Strahan of the University of Georgia, with whom arrangements have been made for testing materials entering into the construction of sand-clay and topsoil roads. "The material for the construction of this type is abundant and may be cheaply manipulated. It is believed that the sand-clay road may be reinforced so as to carry efficiently a heavier traffic by occasionally covering it with a thin layer of stone screenings. With the development of such a reinforcement it may prove to be possible to further extend the usefulness of such a type by some dust-laying application."



AVERAGE TRAFFIC OVER SELECTED ROADS. TAKEN MAY 28-30, 1923.

OTHER TYPES

Sand-clay roads cost about $5,000 a mile for construction, while bituminous-macadam costs about $27,000, bituminous-concrete and Portland cement concrete about $34,000. It is therefore possible to construct many times the mileage of sand-clay roads that could be secured with an equal expenditure for roads of higher types. It is appreciated, however, that more and more of these more expensive roads must be built as traffic increases, and the grades and alignment used in constructing the cheaper roads are such as will be satisfactory for the highest types of surfaces. A very high percentage of the total expenditure is consequently consumed by permanent improvements such as grading and bridges, 38% of the total expenditure having been for bridges alone and 20% for grading; whereas the average for all of the states is 16% for structures and 22% for grading. The large amount spent in bridges is due to the number of important stream crossings in the state and the necessity of constructing new bridges over practically all of them, together with the aim to secure structures which will not have to be renewed under any anticipated development of traffic.



A CONCRETE BRIDGE ON A GEORGIA STATE HIGHWAY.

Roads of the higher types in Georgia do not differ materially from those constructed in other states.

However, there is now being tested out a new type of construction aimed to utilize local materials as a base for these higher types of construction, in place of concrete. This new type of construction consists of first digging out the subgrade to a depth of 10 inches below the under side of the wearing surface, and 18 feet wide, with the sides sloping. The sides and bottom of this trench are then covered with asphaltic oil, preferably sprayed on, so as to make the trench practically watertight The dirt which had been excavated is then replaced and well compacted by rolling and covered with oil, this waterproofing extending beyond the sides of the excavated trench and bonding on to the other oiled surfaces. The aim is to entirely protect this compacted dirt base from water from either above or below. On this is then laid a wearing surface of penetration macadam. A trial section of this was under construction about two months ago when the writer visited Georgia.

CONSTRUCTION

Bids for construction work are received by the State Department from contractors, and also from the county in which the work is to be done, and the work is let to the latter or to the lowest responsible bidder. Many of the counties do not have money available for road work but have convict labor which costs them little, and the letting of contracts to the county has been common in Georgia. Where the county receives the contract, it is required to deposit a sum of money sufficient to enable the state to complete the project should the county for any reason withdraw; this being necessary because the state is required to obligate itself to complete any project undertaken with federal cooperation. Where the contract is let to a contractor, the county is required to deposit a like amount for the same purpose.

In the case of bridge projects and those involving the higher type of surfacing, a resident engineer is assigned on the project and, upon completion, it is inspected by the division engineer and the state highway engineer before being accepted.

During 1920, on account of rising costs of labor and material, a special form of contract was resorted to known as Form B, and was used for a comparatively short time. In the Form B contract the bidder separated his proposal into three major parts: (a) cost of work, (b) rental of equipment, and (c) compensation; the sum of these three constituting his bid or contract price. The first item was obtained in the ordinary way by multiplying the quantity of each item by its unit price and adding the products. The estimated rental cost was obtained by the bidders placing a value on each piece of equipment and stating the time necessary for completing the work and the rate of interest, generally 8%, depreciation and insurance to be included in the rental. The item "compensation" was a lump sum which included the service rendered by the contractor or his organization, this lump sum being named by the contractor. This, however, was increased or decreased in the final payment, depending upon whether the sum of (a) and (b) was greater or less than the corresponding units originally estimated by the contractor; the contractor receiving, in addition to the specified compensation, 25% of any savings, this, however, being limited to 50% of the original compensation bid; and having deducted from the compensation 50% of the amount by which the final cost might exceed the sum of these two items, this deduction being limited to 75% of the estimated compensation. Thus, as a matter of fact, the contractor became an agent for the owner, executing the work and purchasing the material and employing labor under the supervision of the state highway engineer, while the county paid all bills presented by the contractor and approved by the state highway engineer.

This contract naturally involved considerable keeping of accounts and records by both the contractor and the State Highway Department. Eighteen projects were wholly or partly completed under the Form B contracts, involving a total expenditure of about $1,800,000. A careful analysis made recently of the contracts so constructed apparently demonstrated that the use of this form was successful and to the interest of the state under the conditions then existing; but it is not recommended under reasonable normal conditions, as it requires a closer cooperation between the highway department and contractor than it is practicable to obtain on a large scale and under ordinary working conditions. Also, it requires the delegation to the field of men in charge of the work of more administrative authority than is desirable and the services of too many men with extensive training and experience. An average of all of these contracts showed that 11½% of the total cost was paid to the contractors as compensation and 6.7% for rental of equipment; a total of 18.7% for profit, overhead and equipment.

(To be continued)

Distribution of Highway Costs

In a recent report to the Chamber of Commerce of the United States the Joint Sub-Committee on the Taxation of Transportation Agencies announced, as the conclusion of its study of the problem, the following six points:

"1. Each form of transportation should bear its fair share of the burden of public expenditure.

"2. Taxation of common carrier transportation agencies should be simplified as far as possible.

"3. Taxes on regulated common carriers operated for hire should bear a definite relation to gross and net earnings rather than to invested capital.

"4. This requirement can best be met in the case of steam and electric rail common carriers by the imposition of a gross-net tax in lieu of the present levies. Pending full regulation of the motor common carrier, such increases should be made in taxes now levied against it as will bring them an amount equitably proportionate to that which may be assessed against the other carriers.

"5. The entire cost of maintaining the improved highways of the country should be borne from special taxes levied against the road user. Such taxes should be used for no other purpose.

"6. Co-ordination of highway construction and maintenance under centralized administrative agencies is urged to eliminate waste and secure efficiency."

The sub-committee finds that out of a $653,844,823 tax charge for public highways in 1921, $183,000,000 was paid directly by the motor vehicle and the balance from general miscellaneous taxation, to which the motor vehicle contributed largely.

Bureau of Public Roads Report

Summary of report for the fiscal year 1922-1923, showing amount of Federal aid roads completed during the year and to date, research work done and other activities.

The report of the Chief of the Bureau of Public Roads, Thomas H. MacDonald, for the year ending June 30th, 1923 and dated October 15th, was ready for distribution by the Department of Agriculture about December 15th. This is a summary in 32 pages of the work done by the Bureau, of which about 16 pages are devoted to highway matters and the other 16 to farm drainage and irrigation.

The report states that 8,820 miles of roads of all types receiving federal aid had been completed during the fiscal year, which brought the total of completed projects up to 26,536 miles. Of this total, 1,860 miles had been only graded and drained. Of the remaining 6,960 miles, 3,815 were gravel roads, 749 miles were sand-clay, 1,440 miles were concrete, 530 miles were bituminous (concrete or macadam), 79 were brick and 11 were bridges.

In reading the report, we notice that, although the gravel roads constituted more than 50% of all of those constructed with anything further than grading and draining, only one other mention is made of gravel or gravel roads in the report, viz., that the laboratory tests and examinations of materials made by the Bureau, included 177 samples of gravel.

"Researches in the physical field designed to supply scientific data for use in road design have become one of the most important and useful activities of the Bureau. The investigations which have attracted the greatest amount of attention are the tests of effect of impact on road slabs and the tests of bituminous pavements of various composition to determine their relative stability under traffic. The phenomenon that is being observed in the latter investigation is the formation of the familiar 'washboard' wrinkles which appear in the surface of bituminous roads under traffic." During the year, 120 special road slabs were constructed for impact tests.

In connection with these tests and researches, the Bureau has found it necessary to devise special measuring instruments, which has delayed the investigation and taken up much of the time of the investigators, but is considered well worth while. Among these have been a strain gauge for recording graphically the instantaneous deformation due to impact, and an accelerometer to determine the force of impact by measuring the deceleration of truck wheels on contact with the road.

The tests of the relative stability of bituminous pavements were completed, but it remained to study them in order to correctly interpret them. A study of the relative wear of 62 sections of experimental concrete pavement by an especially designed machine, carrying four wheels with solid rubber tires, was completed, the machine having made approximately 50,000 trips at a speed of 22 miles an hour. The results do not warrant drawing any definite conclusion except that under rubber-tired traffic without impact, surface wear is exceptionally slow.

Studies were made regarding effect of alkali upon the strength of concrete; concerning the use of water gas tar and paraffin as protective agents, and concerning the suitability of blast furnace slags as concrete aggregate, indicating their suitability and that the strength is equal to the strength of concrete using other acceptable aggregates. Tests also were made of samples taken from asphaltic pavements in a number of cities and on toughness and adhesiveness of bituminous mixtures, and work on the tests of bituminous materials in cooperation with the American Association of State Highway Officials and the American Society for Testing Materials.

During the year an autographic traffic counter was devised which, when installed in a road, will record the number and weight of all vehicles passing the point of installation, which is expected to make possible a precise knowledge of volume of traffic and weight of vehicular units with a minimum expenditure of effort and money.

The Bureau also cooperated in researches of various kinds with the Engineering Experiment Stations of Purdue University, Iowa State College, University of Texas and Kansas State Agricultural College, and with the University of Georgia, University of Maryland and the Massachusetts Institute of Technology; with the State Highway Departments of Georgia, New Hampshire, Maryland, North Carolina, California and Illinois, the last two in connection with the test roads at Pittsburg, California, and the Bates road in Illinois. The subjects investigated in cooperation with these states and colleges included: The testing of concrete and concrete aggregates, the life of sand-clay and similar roads, resistance of various kinds of road surfaces to traction, effect of impact on highway bridges, investigation of wind resistance to motor vehicles, cause of the disintegration of concrete roads in New York State, and effect of moisture on volume change in soils.

The Department announced that the value of surplus war materials suitable for road work delivered to state highway departments during

the year exceeded $58,000,000, while the total volume of all material delivered up to the end of the fiscal year exceeded $208,000,000. The states receiving the largest amounts up to date were: Texas, $11,855,000; New York, $11,199,000, and Illinois, $9,255,000. The smallest amount was that delivered to Delaware, $494,000, with Rhode Island second and New Hampshire third. Although New Hampshire received a small amount, it is referred to in the report as one that has benefited materially thereby. The state received not only 22 touring cars and 134 trucks, but surplus war equipment has been used in fitting out a repair shop, machine shop, carpenter shop and testing laboratory, and the department is now able to make new parts and thus eliminate delays and reduce repair charges. The North Carolina Highway Department received a large amount of rough castings for spare parts of the motor trucks that were badly rusted and for which the War Department had received an offer of 1c a pound, which parts the State Department, by means of machinery also received from the War Department, finished for its own use, when they were considered as worth 75c a pound.

A considerable part of the report is devoted to a description of investigations made in highway economics, observations from the Connecticut transportation survey and motor truck transportation in New England, and a study of methods of highway finance and of the influence of highway improvement on rural land values.

Depth of Pavement Bases*

Relation of this to the strength of the pavement. Six-inch concrete base suffices for most streets in New York City. Strength increases as square of depth.

By Clarence D. Pollock, M., Am. Soc. C. E.

An old macadam pavement has proven a good foundation in many cases where it was not necessary to make openings in it for sub-surface structures, but usually in city streets the most satisfactory foundation is one of Portland cement concrete, which is generally laid either five or six inches deep on a well compacted sub-grade. Where the sub-soil is of sufficiently porous material to provide good drainage, these depths have proven sufficient even for present day traffic. For instance, in the Borough of Manhattan, New York City, with six-inch concrete foundations, the costs of repairs due to foundation failures have for a considerable period been kept separately, and up to October, 1921, had amounted to less than one-tenth of one per cent. of the total cost of repairs per year. Any increase in depth of foundation here would surely be unnecessary and a waste of money. It is true that New York has generally good sub-soil conditions, but it is an ever-changing city and probably has more construction openings made in its pavements per mile per year than any other city. There is frequent settlement of the sub-soil in these cuts, but the concrete usually bridges over the moderate sized ones and carries the traffic. On Fifth Avenue it was learned that a six-inch concrete foundation had bridged over a span of six feet and carried the traffic of that heavily traveled thoroughfare safely for years, although buses on that street when loaded weigh from eight to ten tons and carry from six to seven tons on the rear axle.

When the sub-soil is of clay or other material which cannot be readily drained, from present knowledge it would seem advisable to improve the sub-grade rather than use a heavier foundation. A dry clay is usually capable of sustaining a load of five tons per square foot, but when very wet the same clay may not sustain more than one ton per square foot. By excavating a few inches additional of the clay and replacing it with sandy or gravelly material, this will distribute the load over so much greater area and effect so much better drainage that a much greater load may be supported.

A rigid foundation cannot act as a beam until the sub-soil gives away sufficiently to allow it to act as such. The better the sub-soil, the greater the load required to deform the foundation. The Washington tests show that with the sub-grade support, the sustaining power of a concrete foundation varies more nearly as the square of the depth than directly as the depth.

Measurements show that the foundation, in transmitting the load to the sub-grade, does not transmit it so that the pressure intensity is uniform. The pressure intensity is highest directly under the load, and spreads over a considerable area, diminishing to nothing at some distance from the load. The intensity of pressure under the load must exceed the bearing value of the soil underneath before the foundation can act as a beam. Even a macadam, bituminous macadam or bituminous concrete foundation will not be deformed until the intensity of pressure directly under the load exceeds the bearing value of the sub-soil.

If the load is stationary or if the surface of the pavement is very smooth, there will be simply the static pressure; but if the surface of the pavement is a little rough there will be impact, and if the surface is quite rough this impact may amount to four to five times the static pressure. This is greatest when the tires are badly worn; with good, well cushioned tires the impact apparently approaches more nearly the static load, and hence the advisability of securing as uniformly smooth a surface to the pavement as possible in order that the impact of moving loads may be eliminated as completely as can be done.

In the Bureau of Public Roads tests with slabs on wet and dry soils, the impact tests punched through the four-inch slabs, but those six inches thick and greater were simply cracked, while those ten inches thick could not be broken by the test apparatus, even on wet sub-grades. According to this, a thickness of ten inches should be sufficient to

*Slightly condensed from a paper before the American Society for Municipal Improvements, entitled, "Relation of Depth of Foundations of Pavements to Their Strength."

carry any load that might come upon the pavement, even with a wet sub-grade. Wet sub-grades are not often found in city streets subject to heavy truck traffic, as the pavement is usually impervious to water, and the sidewalks also. Should there be bad sub-soil conditions, it will generally be found much less expensive to improve the sub-grade than to pay for four extra inches of concrete and the additional four inches of excavation. Such excavation replaced by a porous, coarse-grained material would in most cases be sufficient.

When in exceptional cases it may be necessary to use a greater depth of concrete than six inches, it should be remembered that the supporting power of the concrete foundation varies about as the squares of the depths; for example, 7-inch concrete would have about one and one-third times the supporting power of 6-inch concrete, 8-inch concrete one and three-quarters, 9-inch concrete two and one-quarter and 10-inch concrete nearly three times.

The tests have also brought out the fact that while the compressive strength of 1:3:6 concrete was 50 per cent. of that of the 1:1½:3 concrete, the difference between the beam and slab strength of these two mixtures did not exceed 20 per cent.

In addition to damage from heavy loads, the pavement, including its foundation, may be injured by water entering a clayey or other plastic sub-grade material from terraces or sidewalks and lifting and cracking the foundation and pavement by the swelling of the sub-soil, and sometimes by frost. This is a further reason for improving the sub-soil rather than increasing the depth of the foundation, as even a thick foundation would probably be broken by the heaving of a clay sub-soil when it became wet or frozen. About twenty years ago the author paved several streets with asphalt on concrete foundation in a suburban development, where there was a layer of clay directly under the foundation, and there were wide grass plots back of the curbs. A severe winter following a wet fall caused this pavement to be lifted as much as two inches in places, evidenced around sewer manhole heads. After the frost went out the pavement settled back, but unevenly and cracked badly in so doing.

From our present knowledge we believe that a six-inch depth of foundation is sufficient to carry modern traffic, provided the sub-soil is good; and if it is poor, that it is better to improve the sub-soil than to use additional concrete.

Memphis' New Waterworks*

Pumping plant shows some novel features. Aeration by trickling through four trays. Iron removal by rapid sand filters. Basin with flat slab roof.

By F. G. Cunningham †

In the engine room the principal items of equipment are four 2700 c.f.m. cross-compound steam-driven air compressors, and three 9,000,000-gallon centrifugal secondary pumping units, arranged in a line along the lefthand side of the room as shown in the illustration; while on the right hand are two 15,000,000-gallon cross-compound pumping engines, two 15,000,000-gallon steam turbine centrifugal pumping units, and two Uniflow engine generator sets. The steam ends of all units are toward the central aisle.

Interesting features of the air compressors, manufactured by the Nordberg Manufacturing Company, are the provision, between the high and low-pressure steam cylinders, of a liberal reheating receiver which is expected to superheat the steam entering the low-pressure cylinder from about 40 degrees to 90 degrees. The high-pressure steam cylinder is of the counter-flow type with poppet valves and the low-pressure steam cylinder is of the Uniflow type with Corliss valves.

Each of the centrifugal secondary pumps requires about 50 brake-horsepower at the pump shaft and will be driven by a direct connected reaction water turbine, which will use water bled from the outgoing high-service mains. The tail water will flow through the condenser of the air compressors, acting as cooling water, and will then return to the suctions of the high service pumps. By this arrangement the secondary pumping will be done with less than half as much steam as would be required if the secondary pumps were driven by the best condensing steam turbines, and there is also a gain in simplicity and the elimination of circulating pumps for the compressors. Should it be necessary to use all of the high-service pumping capacity to supply the city in an emergency, the secondary pumps and iron removal plant may be shut down temporarily, when a small amount of high-service water will suffice for the compressor condensors.

The pipe header system and its valves and connections are so arranged that no one break can put more than one pump or supply main out of service. All of these valves have hydraulic operating cylinders and will be controlled from an operating table in the engine room.

A railroad siding approaches within a few feet of the south or boiler-room end of the main station. North of the station is the iron removal plant, and a few feet east of this is the aerator, while immediately south of the aerator is the equalizing basin, occupying the northwest corner of the reservoir, which lies east of the pumping station.

*Continued from page 374.
†Resident supervising engineer for Fuller & McClintock.

AERATOR AND IRON REMOVAL PLANT

The design of the aerator was based upon results from experiments made early in 1922. Aeration will be accomplished by allowing the water to trickle through forty sets of trays, each set consisting of four trays placed one below the other. These are enclosed in a one-story building having large terra cotta grills instead of windows along the sides and with open monitors in the roof. The building is cross shaped in order to secure liberal wall and grill area, the trays being arranged with a view to securing ample circulation of air through and around them. The trays will be constructed with concrete sides and bottoms of brass wire mesh and filled about 10 inches deep with crushed coke. They will be 2 feet by 7 feet in plan and separated 9 inches apart vertically in the clear. Directly over each section of trays will be a distributing box having a perforated sheet brass bottom by means of which the water will be applied to the uppermost tray in small, uniformly distributed streams.

The maximum rate of flow through the trays will be 30 gallons per square foot per minute. The total head loss through aeration will be about 9 feet. It is expected that the aerator will reduce the carbon dioxide from 20 parts per million to 3 or 4 parts.

The effluent from the trays will discharge into a concrete basin below the floor, which is baffled so that it may be used as a reaction chamber if it should be desired to apply lime to the water for the purpose of removing all of the carbon dioxide.

Iron will be removed by means of eight ordinary rapid sand filters. In connection with these there will be an elevated wash-water tank and chemical storage room, and in the same building will be located laboratories, office and toilets. The filters have a total nominal capacity of 18,000,000 gallons daily. Two small dry feed machines are being provided to handle hydrated lime in case this should be used.

The main storage basin, with a capacity of about 9,000,000 gallons and, in one corner of it, an equalizing basin of 1,000,000 gallons capacity, together cover an area of about 300 feet square. They are constructed of reinforced concrete with a flat slab roof, which will be covered with two feet of earth, on which will be located tennis courts as already stated. The function of the equalizing basin is to maintain an approximately constant water level on the suction side of the secondary pumps, compensating for differences between the rate at which water comes in from the wells and that at which the pumps take it out. Normally it will be maintained practically full in order to decrease the lift of the pumps, but in case all available water is needed, as during a big fire, its contents may be thrown into the main basin by opening gates.

All contracts and purchases for these works are being made by the Board of Water Commissioners. The designing and constructing engineers are Fuller & McClintock.

FIRING AISLE IN BOILER ROOM.
Coal bunker is suspended from roof truss.

Denver's Water Supply and the Moffat Tunnel

The construction of the Moffat tunnel is generally thought of as being to furnish access to the coal fields and agricultural resources of northwestern Colorado, and the majority of people are not aware that it will play a very important part in supplying Denver with additional water. The present supply of the city is sufficient for a population of only 500,000 and the only additional sources available are on the western slope of the mountains. The most valuable of the available supplies is that from the drainage area of the Fraser River and its tributaries. To utilize this, however, it would be necessary to pump it over the mountains, which would seem to be impracticable, or else to carry it through the mountain in tunnel; and this latter is made possible by the Moffat tunnel. Thus Denver will adopt the same plan as New York City has done in bringing its additional supply through the mountains by means of the Shandaken tunnel. It is proposed to carry the water through the Continental Divide by utilizing the pilot tunnel to be constructed in building the main railroad tunnel, the tunnels being parallel and about 75 ft. apart. The pilot tunnel will be about 7x8 ft., to be enlarged later when additional capacity is required.

Use of City Water by Contractors

There was a discussion of this subject before the 16th Annual Convention of the Indiana Sanitary and Water Supply Association in which several superintendents took part. W. L. Younce stated that when he first took charge of the department of Newcastle, Indiana, he experienced considerable trouble with contractors breaking off service and valve boxes, or covering them up. He reasoned with them and in some cases had them before the Mayor, who added the authority of his office to the demand that they discontinue these practices, and this in every case had the desired effect. At the present time the city engineer notifies the Water Department whenever a contractor begins work. The contractor can obtain water from a residence that is metered and settle with the property owner, or the department will furnish him with a meter which he attaches to a residence connection. If he wishes more water than can be obtained through a house service, a connection is made to a fire hydrant and the meter attached to this. There has never been any trouble due to a hydrant leaking from this cause. In the case of a fire alarm, the contractor at once disconnects the meter, which he also does each evening and at the noon hour.

William Luscombe of Gary stated that in that city the water is furnished to contractors by meter where practicable, but in some places this is very expensive. In the great majority of cases the Gary water company furnishes contractors with water on a flat rate basis and a large amount of it is wasted. The contractor makes application and pays for water to be furnished for certain purposes connected with the proposed work. A few days later an inspector visits the premises and continues to do so frequently during construction, frequently finding that water is being used for purposes not authorized or in quantities in excess of those applied for. Most of the mains are laid in alleys and at the rear property line. The contractor places a temporary riser pipe and connection and, using 75 feet to 100 feet of ¾-inch hose, conducts the water from this riser pipe to wherever it is wanted. It is not uncommon to find the full flow of the hose being wasted continuously which, if continued during one-half of the working hours of ninety days, the average construction period for an ordinary residence, would amount to $30 by meter; but on a flat rate the contractor pays about $3.50 for it. Where considerable waste is practiced the company furnishes the water at a loss. Where this wasting is discovered the contractor is cautioned and on a third offense the supply is cut off and not turned on again until assurance of reasonable use is given and $1.00 paid for turning on. Only in cases of flagrant violations is the contractor required to take water through a meter, as it costs between $14 and $18 to provide a suitable place for the meter and it is not desired to burden the contractor with this cost if it can be avoided. It does not seem practicable to have the permanent service pipe for the residence and the consumer's meter installed at the outset, since the building is generally well under way before the contract for the service pipe and its trenching is let. Fire hydrants are used only when no other source is available and then only on written order from the fire chief; in which case a spare nozzle cap is converted into a reducer and a small valve is used for controlling the supply.

Mr. Endris stated that in New Albany a yearly permit is issued to each contractor and at the end of the building season they give a statement of the concrete yardage, etc., and pay on that basis.

Dow R. Gwinn stated that in Terre Haute they tried this plan but had found that their faith in human nature was apparently misplaced and now put a meter on the service pipe and charge the property with the amount of water used.

Mr. Reitchmiller, of Fort Wayne, said that in that city a charge of three-quarters of a cent per yard of concrete was made for paving streets and sidewalks. For other purposes water is obtained through a regular house service, either a permanent service for the building under erection, or one already installed in the adjacent property. No one is allowed to use hydrants except the fire and street-cleaning departments, and they are hoping to eliminate the latter.

Pumping Plants for Well Supplies

In a recent letter discussing some features of waterworks plants using ground water supplies, a western contractor has called to our attention the desirability of postponing final designs, or at least the awarding of contracts, for pumping plants that are to draw from wells, until one or more wells have been driven and the amount of water available and the depth from which it must be drawn definitely ascertained. This contractor states that during the past two years there have come to his notice instances of several installations made by smaller cities wherein this mistake had been made. In one case the city had purchased pumps and laid three miles of main from the town to the site selected for its wells before the wells had been driven and had also built an electric transmission line for operating the pumps. When the well had been driven it was found that the water at that site was entirely inadequate but later a good supply was obtained in an entirely different location. This necessitated removing and relaying the discharge line, rebuilding the transmission line and the purchase of new pumps, since the ones already obtained were not suitable for the changed conditions.

In another case a 12-inch pipe line and a power transmission line were carried for a distance of 9 miles and a large pump and motor bought and placed in a 20-foot pump pit and a suction line laid 20 feet below the surface from the pump to the location selected for the wells. When the wells were built and connected up they also were

found to be of insufficient capacity. In each case the large sums wasted could have been saved had the wells been driven and tested before final plans were made for the pumping plants.

The point seems to us very well taken. The underground conditions in many if not all sections of the country are so insufficiently known and vary so from point to point that it is frequently impossible to tell without actually constructing and testing a well, whether this location will be a favorable one for locating the well system, and if so, to what depth it will be necessary or most economical to lower the groundwater in obtaining the desired supply; and until these are known it is not possible to plan the most suitable, effective and economical pumping plant, or to decide just where to place it, either as to location or to depth below the surface.

Water Meters and Consumption in Ohio

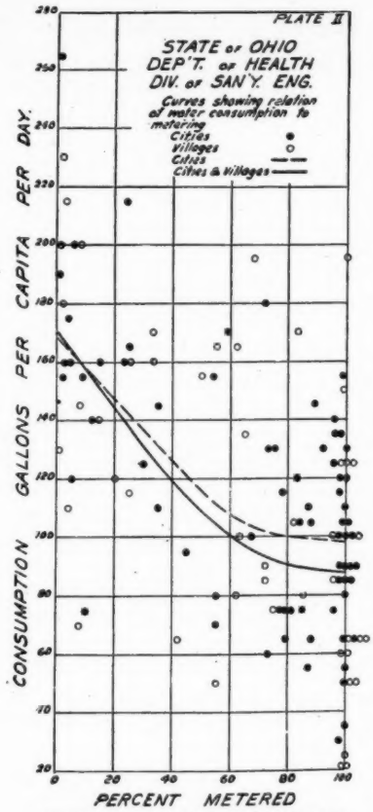
Information from 150 cities and villages, classified and combined, shows relation between consumption and percent of services metered.

A study of water meter installations and rates has been undertaken by the State Department of Health of Ohio as a result of a request for information by various communities of that state. The result of the study has been reported by E. I. Roberts, assistant engineer of the Department.

The study covered 150 cities and villages of 2,000 and more population. The information was obtained by means of a questionnaire and also from the monthly reports on the operation of water purification plants made to the State Health Department and from records of investigations that had been made by representatives of the Department.

For the purposes of comparison the cities were divided into six classes, Class A including all of 50,000 population or more; Classes B and C of 15,000 to 50,000, the former using filtered water and the latter well water; Classes D, E and F those of 5,000 to 15,000, Class D filtering water, Class E using well water and Class F using unpurified surface water; while Classes G and H represent villages of 2,000 to 5,000 population, the former filtering water and the latter using well water. There were found to be 9 cities in Class A, 11 in B, 9 in C, 16 in D, 37 in E, 9 in F, 14 in G and 45 in H.

The figures showed that those communities that were 100% metered had an average daily consumption of 90 gallons per capita, and, on the other extreme, those with no meters averaged 170 gallons. The accompanying diagram shows the relation between percent metered and consumption in the various cities and villages. The comparison is complicated by the use of water for manufacturing purposes, the use of private supplies for such purposes and for residences, the different extents to which the villages are sewered, the character of the water, and unaccounted for water (mostly leakage). For this reason the Department's engineers have not endeavored to make any predictions of the extent to which water consumption could be reduced by metering. The diagram shows a lower consumption for cities and villages 100% metered when combined than for cities alone, and it is suggested that this probably is due to the lack of sewerage systems in many of the villages.



EFFECT OF METERING ON WATER CONSUMPTION.

Tables are given showing the rates for each of the 150 communities. Taking the averages for all of each of the several classes, weighted according to the populations, we have the rates per thousand gallons for domestic consumers as follows:

A—15c., B—32c., C—22c., D—37c., E—29c., F—23c., G—71c., H—41½c. The 71c. average is due to the high rate charged by one village of the fourteen, $3.00. If this one be omitted, the average becomes 48c.

Street Signs in San Francisco

The city of San Francisco has recently erected in the downtown district 371 street signs of the most modern pattern at a cost of about $7,000. Each sign consists of four 5-inch x 22-inch porcelain enamel plates containing 3-inch white lettering on a blue background mounted in metal frames, supported by a 3-inch pipe standard set in concrete so that the sign is 9 feet above the sidewalk level. A study has been made with a view to preparing a systematic location of signs throughout the entire city, which will be carried out as funds are available. It is hoped to obtain an appropriation of $10,000 annually for the next three years, which will permit putting the city into an excellent condition as to signs, after which the cost for new signs and upkeep will be little more than nominal.

Milwaukee's Sewage Disposal Plant.

Detailed description of the largest activated sludge plant yet designed, after years of investigating and testing numerous methods and appliances. Grit chambers, fine screens, aeration tanks, vacuum filters, driers, pumps and other machinery.

It is just ten years since the city of Milwaukee, through its newly created Sewerage Commission, began a systematic and searching study of the problem of how best to treat the sewage of the city before discharging it into Lake Michigan. During this time, with T. Chalkley Hatton as chief engineer and an organization of engineers, chemists, biologists and other specialists, it has conducted the investigations, chiefly by means of a sewage disposal testing station. The year 1914 was largely devoted to the construction of the testing station on Jones Island and the beginning of experimental work. In 1915 preliminary laboratory studies were made on the activated sludge process, then recently discovered, and these proved so promising that larger tanks were constructed and the process intensively studied on a practical working scale. By the end of 1917, the Commission, upon recommendation of its chief engineer, had about determined upon this process but, before taking final action, thought it desirable to run the demonstration plant for at least another year. After two years of practically continuous operation the Commission formally adopted the activated sludge process on December 31, 1919. Following this, further examinations and tests were made to determine the most practicable, effective and economical details of construction and operation, including especially methods of dewatering the sludge, and the possibilities of producing a commercial fertilizer therefrom.

In July, 1921, the Legislature created a Metropolitan Sewerage Commission to plan and construct in the county of Milwaukee, outside the city limits, main sewers to bring to the Milwaukee sewage treatment plant the sewage from these outlying sections. With the addition of this outlying territory, the domestic sewage and industrial wastes from a population of approximately 575,000 people on an area of 96,800 acres will be brought to the disposal plant. It is estimated that the amount of sewage delivered to the plant will be about 75,000,000 gallons daily.

The disposal plant has been under construction for some time and it is expected that it will be ready to go into full operation early in 1925. In the following paragraphs will be described the plant as it has finally been decided upon.

GENERAL TREATMENT PROCESS

The testing station was located on Jones Island, which lies between Lake Michigan and Kinnickinnic river, with the harbor entrance directly north of it. The permanent plant will be located immediately south of the testing station and will be surrounded by a government pier on the north side and a concrete dock wall and a bulkhead of stone and wooden piling on the other sides. The testing station and the land on which it was built will be removed, bringing the harbor down to the government pier.

The sewage will be brought to the Island from the mainland through two low-level siphons and two high-level, laid under the harbor 75 feet below water-level.

On reaching the plant the sewage will pass through bar screens, grit chambers and fine screens and thence into the activated sludge tanks. From these tanks the effluent will pass into the lake. That part of the sludge that is not returned to the tanks will be pumped to a filter house where it will be dewatered, dried, screened and put into condition for sale as material for fertilizers. The standard of purification from raw sewage to effluent adopted by the Commission is 90% reduction of bacteria, 95% reduction of suspended matter and a stability of 72 hours. The operation of the demonstration plant indicates that these averages will at all times be surpassed if the plant is maintained at a high state of efficiency.

DESCRIPTION OF PLANT

The following description gives in some detail the main features of the plant, reference being made by number to the location of them as shown on the accompanying map.

The Park Street siphon (1) is a double concrete sewer built in tunnel, the high-level sewer being equivalent to 48 inches diameter and the low-level equivalent to 54 inches. The Erie Street siphon (2) is similar to the other but the high-level has a size equivalent to 72 inches and the low-level to 42 inches diameter. The maximum capacity of the four siphons is 317,000,000 gallons daily. The high-level sewage, about 80% of the total, will flow to the plant by gravity but the low-level must be pumped.

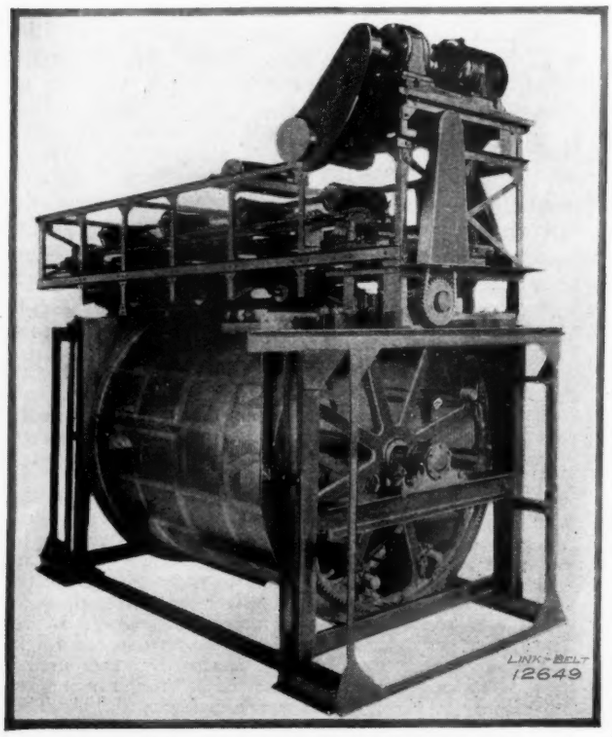
In the coarse screen house (3), the high-level sewage passes through rack screens and the low-level sewage through two cage screens. Vertical high-level risers (4) discharge the sewage into a high-level flume (6) 10 feet wide and 6 feet deep, across which the rack screen is located; while two low-level risers (5) deliver the low-level sewage to the cage screens. The rack screens (7) consist of vertical bars 2″x½″ placed edgewise to the flow spaced 4 3/16″ center to center. These will be cleaned by rakes used by hand. The cage screens are made of ¾″ round bars spaced 2¾″ center to center and forming a frame 9′x10.′ There are two chambers with two cages in each, one cage being down and in operation while the other is raised by hoisting engines for cleaning.

A concrete tunnel, 72" diameter (9), carries the low-level sewage from the cage screens to the suction chamber of the pump well (10). This well is circular, 45' in diameter and 35' deep, and is lined with white tile. From this well the low-level sewage will be lifted 25' to 30' into the high-level flume.

The low-level pumps are housed in a brick power house (11), 200' long, 93' wide and 42' high, which also encloses the return sludge pump well, the turbo-generators for furnishing power and the turbo-blowers which supply air to the aeration tanks and channels. In the 48" cast-iron pipe (12), through which the low-level pumps discharge to the high-level flume, is a Venturi meter for measuring the volume of sewage pumped. Leaving the high-level flume, the sewage passes through the upper part of a double concrete flume (13) to the tanks; the lower part of the double flume serving as a plant bypass, this bypass being 10' wide and 5' deep.

The grit chambers (14) consists of eight open concrete channels, 8' wide, 8' deep and 95' long. In these the velocity of the sewage is reduced to from 1 foot to 0.74 foot per second. The matter settling here is to be removed by means of a clamshell bucket operated by a locomotive crane, the channel to be cleaned having previously been isolated and drained. From the grit chambers the sewage passes to eight fine screens of the Tark type (16). This is the first large plant in which these screens have been used and the first in which all of the later improvements have been embodied.

These screens are of the drum type manufactured by the Link Belt Company. Each screen is in the form of a drum or cylinder, 8' in diameter and 8' long, the screen portion consisting of a series of slotted plates mounted on a frame attached to a steel shaft on which it revolves, the shaft being mounted in Hyatt roller bearings. The drum is submerged for nearly its entire diameter in the sewage and, to prevent the entrance of sewage into the bearings, an oil seal is provided. The sewage enters through the slots, which are 1/16 inch in width, and passes out through one end of the drum, which is entirely open. The screen differs from others of the drum type in that it is almost entirely submerged and therefore a large percentage of the area is available continuously for screening, thus reducing the total area of screen surface necessary for clarifying a given amount of sewage. The slotted plates are made in small sections, each of which can be handled by one man and can be readily removed at any time should this be necessary. To prevent galvanic action, brass supports are provided for these plates and the threads for the screws that hold these plates are tapped into these supports. The drum revolves in a chamber, the bottom of which is cylindrical and a few inches from the surface of the cylinder. Eight plates known as sludge plates extend from the surface of the cylinder almost touching the bottom of the chamber and carry with them all such solid matter as may settle in this chamber, which matter, when it reaches the top of the screen, is removed along with the finer matter which has collected on the surface from the sewage that entered through the slots. The sludge plates, by means of a simple contrivance, withdraw into the drum just before reaching the cleaning brushes, and again assume their position after passing the brush.



GENERAL VIEW OF ONE FINE SCREEN, MILWAUKEE SEWAGE PLANT.

The material collecting on the outside of each screen is removed by means of eight brushes which are carried across the drum parallel to the axis by means of two continuous link belts, to which they are fastened. The rate at which the brushes travel across the screen can be adjusted by varying the speed of the link belt. The brushes and belt are mounted on a steel frame which spans the opening in which the drum is installed. The weight of the brush does not come upon the screen plates but is carried by rollers on a track, and the pressure on the screen can be adjusted to anything desired and wear of the bristles compensated for. As the brushes pass across the screen they revolve and brush the screenings ahead of them and into a conveyor by which they are removed to any point desired.

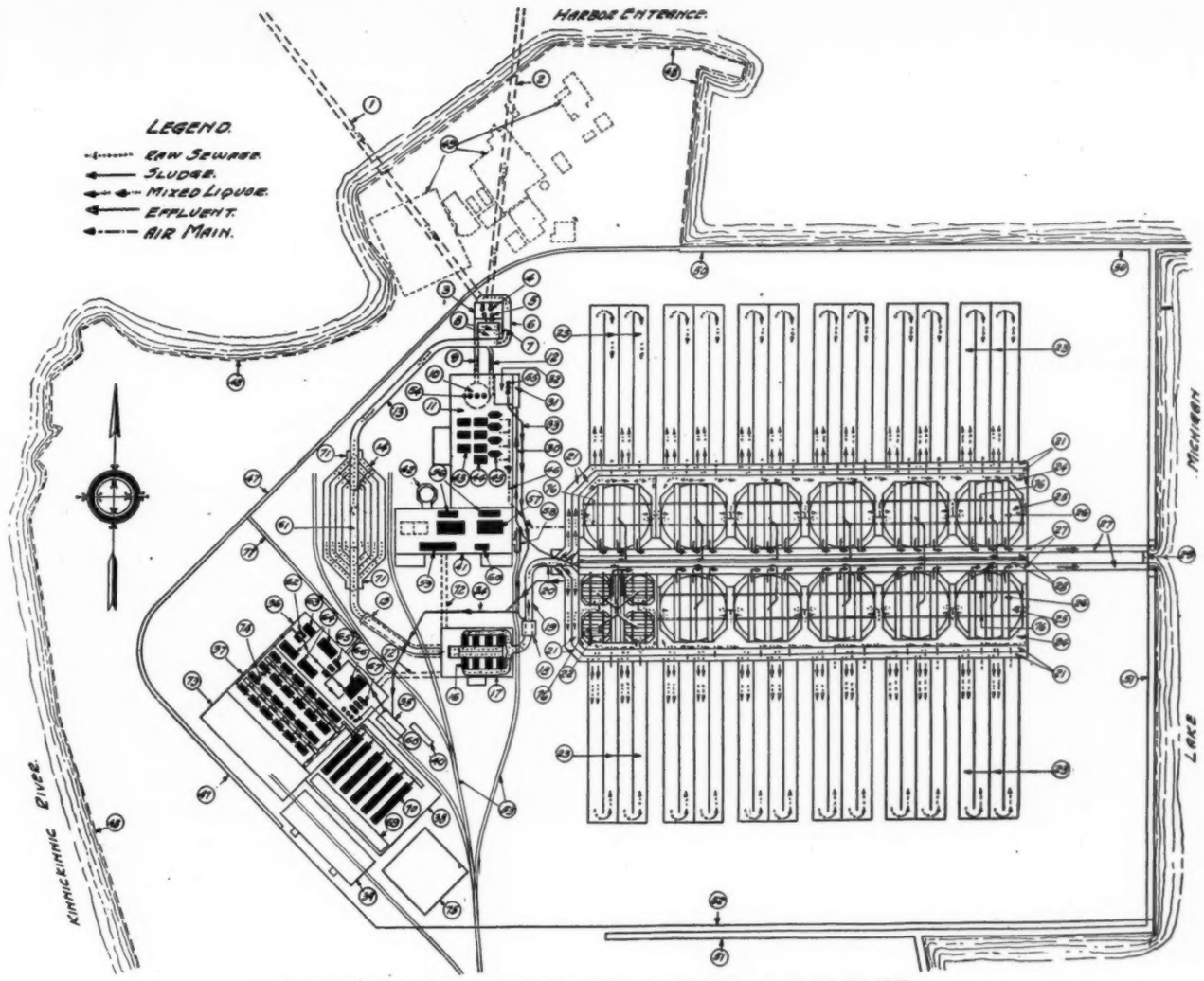
The drum is driven by an electric motor through gears on the driving pinion, this as well as all the rest of the mechanism being above the surface of the sewage and readily accessible. The only parts of the entire installation that are immersed are the drum itself and its bearings.

The fine screens are enclosed in a brick building (17), 100 feet long, 68 feet wide and 42 feet high. This building will be in two stories, the upper one of which will be used for the laboratory and administration offices. Beyond the screens is an overflow chamber (18) arranged with weirs which will bypass part of the storm water flow. All of the storm water will pass through the grit chamber and fine screens but not through the aeration and sedimentation tanks.

From the tanks the effluent will flow through a mixing channel (19), a concrete conduit 14' wide by 11' deep with a maximum capacity of 231,000,000 gallons daily, in which the screened sewage will be mixed with returned activated sludge, which sludge will amount to from 15% to 20% of the amount of sewage. This mixture of sewage and sludge is called "mixed liquor." The "mixed liquor" passes into four feed channels (21) which are controlled by 6'x10' sluice gates. These channels are of concrete, 8' wide, 10' deep and 790' long. They supply the mixed liquor to the aeration tanks.

There are 24 aeration tanks (23). Each is a rectangular concrete tank with two parallel compartments, 236' long, 22' wide and 15' effective depth. In the bottom of each tank will be 2,514 filtros plates, each one foot square and held in precast concrete containers. Air compressed to 8 or 10 pounds per square inch pressure will be supplied to and diffused through the filtros plates. After six hours contact with the air and return sludge in these tanks, about 95% of the organic matter in the raw sewage is in condition to settle out and the mixed liquor then passes through mixed liquor channels (24) which carry it to the sedimentation tanks (25).

There are eleven sedimentation tanks of concrete, each 98 feet in diameter at the bottom, with octagonal tops and an effective depth of 15 feet. These tanks are equipped with Dorr thickeners. (These thickeners were described in "Public Works" for January 15th, 1921). After remaining in the sedimentation tank about 30 minutes, the granular precipitate settles to the bottom and the purified effluent flows out at the top into the effluent troughs (26). These consist of three steel troughs at the top of each sedimentation tank, 32" wide, 18" deep and 98' long, which carry the effluent to the two effluent channels (27) which are constructed of concrete, 8' wide, 16' deep and 800' long. These convey the effluent to the lake outfall (29), through which it will be discharged into the lake at a depth of 14 feet below water-level.



DIAGRAMMATIC PLAN OF MILWAUKEE ACTIVATED SLUDGE PLANT.

(1)—Park street siphon.
(2)—Erie street siphon.
(3)—Coarse screen house.
(4)—High level risers.
(5)—Low level risers.
(6)—High level flume.
(7)—Rack screen high level.
(8)—Cage screens low level.
(9)—Conduit to low level pump.
(10)—Low level pump well.
(11)—Power house.
(12)—Return conduit from low level pump.
(13)—Sewage channel (above), by-pass (below).
(14)—Grit chambers.
(15)—Overflow chamber.
(16)—Fine screens.
(17)—Fine screen house and administration building.
(18)—Overflow chamber.
(19)—Mixing channel.
(20)—Gate house.
(21)—Feed channels.
(22)—Sludge conditioning tanks.
(23)—Aeration tanks.
(24)—Mixed liquor channels.
(25)—Large sedimentation tanks.
(26)—Effluent troughs.
(27)—Effluent channels.
(28)—Return sludge channels.
(29)—Outfall.
(30)—Return sludge channel to pump well.
(31)—Sludge suction chamber.
(32)—Return sludge pump well.
(33)—Return sludge main to mixing channel.
(34)—Sludge pipe to filter house.
(35)—Acidification tank.
(36)—Machinery bay.
(37)—Filter house.
(38)—Dryer house.
(39)—Coal storage pocket.
(40)—Acid storage tank.
(41)—Boiler house.
(42)—Stack.
(43)—Turbo generators.
(44)—Turbo blowers.
(45)—Air washers.
(46)—Air main.
(47)—Dock.
(48)—Present river line; to be removed.
(49)—Testing station to be removed.
(50)—Government pier.
(51)—Bulkhead.
(52)—Property limit.
(53)—Railroad tracks.
(54)—Low level pumps.
(55)—Return sludge pumps.
(56)—Economizers.
(57)—Boilers.
(58)—Track hopper.
(59)—Water softener.
(60)—Feed water heater and pumps.
(61)—By-pass.
(62)—Condensers—pre-heaters.
(63)—Generator.
(64)—Vacuum pumps and air compressors.
(65)—Condenser and sludge pumps.
(66)—Heat exchanger.
(67)—Condensers.
(68)—Receivers.
(69)—Coal hopper and stokers.
(70)—Dryers.
(71)—Gate house.
(72)—Service pipe tunnels.
(73)—Machine repair shop.
(74)—Oliver contin. filters.
(75)—Dried sludge storage bldg.
(76)—Dorr thickener trusses.
(77)—Filtrate outlet.

The sludge settling in the sedimentation tanks is removed continuously from the bottom, under pressure of the hydrostatic head, into two parallel concrete conduits, 6′ wide and 11′ 6″ deep, known as "return sludge channels" (28), which pass through the entire length of the center gallery and are equipped with diffuser plates. From this the sludge flows through a 54″ channel to the sludge well (31) in the northeast corner of the power house, from which the sludge is pumped back into the mixing channels. For returning the sludge, three Allis-Chalmers automatically controlled, single-stage, double suction, vertical shaft pumps are used, each having a capacity at full speed of 12,000,000 gallons daily. Each pump is driven by a 50-h.p. variable speed, 3-phase, alternating current induction motor. These pumps discharge into a 48″ cast-iron pipe (33), equipped with a Venturi meter, which pipe carries sludge back to the mixing channel. The excess sludge is carried by an 18″ cast-iron pipe to the acidification tank. This tank is a 42,000-gallon submerged reservoir, wherein acid is added prior to filtering; diffuser plates being provided to prevent sedimentation and to promote mixing of sludge and acid.

From this tank three Allis-Chalmers motor-driven centrifugal pumps (65) pump the sludge through heat exchangers (66) and preheaters (62) to the filters. When the sludge is not to be heated, these pumps will supply the water for the condensers for the turbo-generator. Ten Griscom-Russell Company heat exchangers having a total heating surface of about 19,500 square feet are used, which will raise the temperature of the cold sludge from about 50 degrees F. to 140 degrees, using for this purpose the heat in the hot filter effluent which enters the exchangers at 160 degrees F. and leaves them at 62.5 degrees. There are two preheaters (62), one as a reserve, to be used in connection with the heat exchangers whenever it may be found advantageous to heat the sludge for more efficient filtration. The preheater also may be used as a condenser only when the heat exchangers are bypassed.

The filters (74) are 24 in number, being Oliver Continuous Filter Company vacuum drum filters, each 11′ 6″ diameter and 14′ long, with 495 sq. ft. effective filtering surface. These are expected to dewater the sludge from 98% or 99%, as received from the sedimentation tanks, to a ribbon-like cake containing from 75% to 80% moisture. The Oliver continuous filter consists of a drum or cylinder rotating on a horizontal axis with the lower portion submerged in a tank containing the liquid sludge. The surface of the drum is divided into compartments or sections, the dividing partitions of which are parallel to the main shaft. The surface of the drum is covered with screens for supporting the filter medium, which is held in place and protected from wear by a wire winding. Each section of the drum is connected, by means of pipes passing through a hollow trunnion, to an automatic valve, which controls not only the application of vacuum for sucking the sludge onto the filter medium, but also admits air for discharging the cake. This vacuum sucks the sludge against the surface of the drum, the liquid passing through the filter medium while the solid matter is left on the outside, where it forms a thin cake. A scraper is fitted across the face of the drum and rests against the wire winding in such a manner that the cake or "ribbon" of dewatered sludge is removed from the drum, the vacuum having been released.

The cake from the filters passes to six Atlas Dryer Company direct-indirect-heat continuous rotary dryers (70), each 7′ in diameter by 60′ long and enclosed in brick settings. As the drum revolves, the hot gases from the furnaces mixed with large volumes of outside air circulate around and into the drum through numerous air valves attached to the drum shell. These will deliver the finished material with a moisture content of only 5% to 10%. From these the material will pass to a dried sludge storage building (75). It is estimated that 1¼ tons of this dry tankage will be obtained from each million gallons of sewage and that therefore an initial production of 100 tons daily may be expected, which will increase as the population increases. The excess water from the filters will be practically sterile, due to the heat and acid treatment of the sludge, and will be discharged into the inner harbor.

Other machinery and equipment used in connection with the units described above are as follows: Three Allis-Chalmers Company horizontal high-pressure continuous turbo-generators, each with a capacity of 625 k.w. Four Ingersoll-Rand Company blowers, turbo-type, each direct-connected to an Allis-Chalmers horizontal high-pressure multi-stage steam turbine operating at 3,600 r.p.m.; each blower having a capacity to compress 35,000 cubic feet of free air per minute to 10 pounds pressure. It is estimated that the air required for 85,000,000 gallons of sewage is approximately 127,500,000 cubic feet. Four Spray Engineering Company air washers (45), located in the inlet pipes to the blowers, will deliver air without free moisture or dirt; not more than 10 gallons of water being required to wash 1,000 cubic feet of air so as to prevent clogging the filtros plates. From the blowers the air will be carried by a 72″ cast-iron air main (46) to the approximately 75,000 filtros plates. Three Allis-Chalmers Company automatically controlled, single-stage, vertical shaft, centrifugal pumps, each driven by a 250-h.p. variable speed, wound rotor motor and having a capacity at full speed of lifting 30,000,000 gallons per day through 35 feet. Three Worthington, Laidlaw type, duplex, 2-stage, reciprocating, vacuum pumps (64), operated by unaflow prime movers and having a piston displacement of 10,400 cubic feet per minute each, which will provide the high and low vacuums for the vacuum filters. Two Worthington, Laidlaw type, synchronous motor-driven air compressors having a piston displacement of 625 cubic feet per minute at 100 pounds pressure.

The boiler house (41) is a brick structure, 165′ long, 68′ wide and 55′ high inside, connected with which is a brick stack 211′ high with an inside diameter of 12′. In this are four Heine 784-h.p. boilers (57), each with a total heating surface of 7,840 square feet and designed for a working pressure of 225 pounds per square inch at 518 degrees F., with an overload rating of 200% continuously. Each boiler is provided with a 7-retort Westinghouse underfeed stocker, a turbine-driven forced draft fan of the Sturtevant type, and a Foster superheater. Diamond soot blowers are provided for removing soot from the boilers. Ash hoppers are furnished by the Baker-Dunbar-Allen Company. Ashes and soot will be removed by means of a Conveyors Corporation of America steam jet ash and soot conveyor. The coal-handling equipment, furnished by the Chain Belt Company, consists of a track hopper (58), a coal crusher with a capacity of 35 tons per hour, a positive discharge bucket elevator, a belt conveyor with automatic tripper, and a coal bunker of 650 tons capacity. A water softener (59) is furnished by the Wayne Tank and Pump Company and consists of two vertical, circular, pressure filters, 96″ diameter, and two vertical, circular, water softeners, 96″ diameter, using the cold zeolite process. Two Cochrane multi-feed water heaters (60); two Allis-Chalmers single-stage, low-lift, motor-driven centrifugal pumps; two 5-stage, motor-driven centrifugal pumps; and one 5-stage steam turbine-driven centrifugal boiler-feed pump are provided.

In designing the plant, certain basic data were first decided upon. Some of the more fundamental were the capacity of grit chamber and fine screens of 317,000,000 gallons daily, and capacity of aeration and sedimentation tanks of 85,000,000 gallons daily on the average with a maximum of 128,000,000 gallons. The rate of treatment in the aeration tanks was taken at 15,000,000 gallons per 24 hours per acre; the time of detention in the tank approximately 6 hours when carrying 20% by volume of activated sludge. The diffuser area is one-quarter that of the liquid surface. It was estimated that the air required would be 1.5 cubic feet per gallon of sewage treated. The effective depth of aeration tank was set at 15 feet and the surface area of each tank at approximately 10,000 square feet.

For the sedimentation tanks the rate of sedimentation was fixed at 1,600 gallons per square foot of liquid surface per day and the maximum velocity of flow through the tanks at 1.5 feet per minute. Each 98-foot tank was given a surface area of 8,550 feet and a depth at the center of 15 feet, giving each tank a capacity of 13,680,000 gallons per day of a mixture containing 20% by volume of sludge.

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CONTENTS

NASHVILLE-SPRINGHOPE HIGHWAY. Illustrated. By Frank W. Skinner 1
Clifford Older Resigns 5
University of Tennessee Course in Highway Work.. 5
Civil Service Examinations 5
City Engineers for Camden 5
Road Construction in the South 5
Denver's Paving Program 6
Effect of Bituminous Roads on Fish 6
Asphalt Macadam in Nevada 6
Sanding Oily Streets, Illustrated 7
GEORGIA'S STATE HIGHWAYS. Illustrated..... 7
Distribution of Highway Costs 10
BUREAU OF PUBLIC ROADS REPORT..... 11
DEPTH OF PAVEMENT BASES. By Clarence D. Pollock 12
MEMPHIS NEW WATERWORKS. Illustrated. By F. G. Cunningham 13
Denver's Water Supply and the Moffat Tunnel 14
Use of City Water by Contractors 15
Pumping Plants for Well Supplies 15
WATER METERS AND CONSUMPTION IN OHIO. Illustrated 16
Street Signs in San Francisco 16
MILWAUKEE'S SEWAGE DISPOSAL PLANT. Illustrated 17
EDITORIAL NOTES 21
Importance of Gravel Roads—Rural Light and Power.
A Curious Coincidence in Bids 22
City Plan Revisions 22
City Bureau of Claims 22
FERTILIZING VALUE OF ACTIVATED SLUDGE 23
Sewage Treatment in Texas 24
Repairing New York's Sewers 24
Biology of Sewage Plants 24
Fly Nuisance at Disposal Plants 25
Portable Elevator for Sewer Settling Chamber. Illustrated 25
Large Railroad Terminal in Dallas 25
CHINA BASIN TERMINAL. Illustrated. By Charles W. Geiger 26
STRENGTH OF CONCRETE 28
Birmingham Waste Utilization 29
Garbage Collection in Los Angeles 29
Concrete Roads in 1923 29
LATERAL EARTH PRESSURES 29
RURAL DISTRIBUTION SYSTEMS FOR ELECTRICITY 30
RUBBER PAVEMENTS. Illustrated 31
Asphalt Pavements in 1923 32
Concrete Pavements in 1923 33
Canadian Highways 33
STRUCTURAL DESIGN OF HIGHWAYS 33
INTERESTING ROAD WORK IN NORTH CAROLINA 34
COARSE BINDER IN PHILADELPHIA 34
THE MOCCASIN CREEK POWER PLANT. Illustrated 35
RECENT LEGAL DECISIONS 37

Importance of Gravel Roads

In a statement made late in October by Thomas H. MacDonald, chief of the U. S. Bureau of Public Roads, the completed road construction program for 1923 is given as approximately 40,000 miles of surfaced roads. In 1922 about 37,000 miles were constructed, divided as follows: 6,000 miles of brick, concrete, sheet asphalt and bituminous concrete; 4,000 miles of macadam, either waterbound or bituminous; 20,000 miles of gravel, and 7,000 miles of sand clay and topsoil.

It is seen from this analysis that the gravel roads last year (and Mr. MacDonald states that the classification in 1923 would show about the same proportions) exceeded in mileage all other classes of road construction combined.* From this it is seen how important it is that the construction and maintenance of gravel roads be given as much attention by highway engineers and investigators as the more expensive but much less numerous pavements of concrete, bituminous materials, brick, etc.

While the construction of a bituminous-concrete or cement-concrete pavement is fairly well standardized, that of a gravel road has many variations. In general, such roads are built by states and counties that are less able to raise large sums for road construction and to which a saving of only a few dollars a mile would be an important matter. These and other considerations would seem to indicate that investigation of construction methods of gravel roads in order to evolve those that are most effective and least expensive is of even more importance than in the case of the more durable and expensive pavements.

An illustration of the widely varying practices in connection with gravel road construction is offered by Nevada. Here the climate is so dry that it is impracticable to count upon rain for wetting the road metal during construction or to haul water from long distances for that purpose. The State endeavored to use methods employed elsewhere but "learned by costly experience that to require the contractor to sprinkle and roll a gravel road runs the cost up beyond reason and does not even then secure a fully compacted roadway; therefore, during the past two years the policy has been to require only the placing and shaping of the gravel surface by the contractor, the final compacting to be done under special arrangement with the government during the following winter season." A gravel road requires two winter seasons before it is fully compacted. It is of course inconvenient for the traveling public in the meantime, but the highway department considers this as unavoidable and reports that following the second winter the roads are "as smooth and hard as concrete pavement." This statement was made by the Nevada state department in reply to criticism that certain new gravel roads

*See also a synopsis in this issue of Chief MacDonald's latest report, received since the above was written.

appeared to be a "hopeless rut of loose gravel, in some cases worse than the old earth road."

The same considerations apply to sand-clay also. Although these roads are not so generally used as gravel, in some of the South Atlantic states they by far outnumber all others.

Rural Light and Power

As we stated last month, with the increasing use of highways the need for lighting them is becoming more pressing and means for doing so are being devised. At least two large companies are prepared to furnish lighting units designed especially for highways.

The cost of poles and wires for furnishing current along hundreds of miles of highways has undoubtedly been a deterring consideration. In this issue we describe a method employed in Ontario whereby poles are entirely eliminated, with their cost of installation and upkeep and objectionable appearance.

If current be furnished from the highway cable to farmers along the way for light and power, it may be found that the net cost of highway lighting is not so great, after all.

A Curious Coincidence in Bids

The Board of Public Works of Los Angeles makes a practice of posting on the walls of the office of each member of the Board, in the City Hall, copies of all bids received and contracts let for the new outfall sewer.

Recently bids were asked for 270,000 brick and each brick dealer was required to sign, in connection with his bid, a statement that in making his bid there had been no collusion with any other bidder. Four bids for these brick were received, and the notice above referred to gave the four bids as follows: $5467.50; $5467.50; $5467.50 $5467.50. Considering that the bidders certified that there had been no collusion between them, this seems to be one of the most remarkable coincidences that we have ever run across. In deciding which company to award the contract to, the Board wrote the names on four slips of paper, put these in a hat and drew one of them. It is reported that none of the companies objected to this manner of deciding the successful bidder; which perhaps is not to be wondered at by those who are familiar with the inwardness of similar occurrences in other cities.

City Plan Revisions

All laws and ordinances establishing city planning provide, we believe, for revisions from time to time of the plan as adopted. Such revisions are liable to become necessary in any plan, for no foresight is sufficiently intelligent or prophetic to foresee all changes in customs or in developments in the area involved.

Several revisions have been necessary in the Philadelphia plan. One of these was to provide for the traffic that will result from the construction of the Delaware River bridge, a part of this revision being the widening of Spring Garden street to 120 feet between 5th and 6th streets, and continuing it at this width from 5th street to Delaware avenue.

Another revision has been made in South Philadelphia, which was planned, with wide streets and diagonals, for a high-class residential district. The Bureau of Surveys reports: "Subsequent developments have, however, changed the probable character of this section of the city and the street system as confirmed would be uneconomical and unsuitable to the requirements of the district as indicated by recent data. All indications point to an intensive industrial development" and a great railroad yard and terminal docks will be constructed along the curve of the Delaware on the southeastern front of the city. The Board of Surveyors has confirmed a number of changes, including striking from the plan a great many streets, keeping only those essential for travel, "thus throwing open for industrial development a large area contiguous and available to harbor facilities along the Schuylkill River."

City Bureau of Claims

The city of Philadelphia has inaugurated a new City Bureau of Claims, following a record year of damage claim awards amounting to over $540,000 in 1919. This bureau came into existence in 1920 with a remarkable reduction in size of verdicts, those for the first six months of 1923 averaging $658.45, while in 1919 the average had been $1,916.73. The number of cases, however, is increasing, and in November it had 1,400 cases on its file, which will probably require more than a year to dispose of.

These results are obtained by the co-operation of bureaus associated with the Department of Public Works and Public Safety and various agencies for checking professional litigants. The establishment of the Bureau of Claims brought an end to the referee system with its practice of percentage fees based upon awards. A policy of vigorous investigation of records was established to eliminate professional litigants and witnesses. Many settlements have been made at figures mutually agreed upon without the cost of litigation.

However, the city did not rest here but is proceeding with a program of removing the possible causes of damage claims. Checking up dangerous conditions and following this with prompt emergency repairs is a part of the co-operation between the Bureau of Claims and the Highway Bureau. The Bridge and Sewer Division received 500 complaints of manhole and inlet covers in 1922, 30% being of misplaced inlets, 40% to broken manhole covers and 30% to missing covers, many of which are removed by boys endeavoring to recover lost balls and other lost articles.

To reduce these causes of complaint, the Highway Bureau on July 1 increased the strength of inlets and covers, one type of covers being increased from 197 to 208 pounds and the frames from 174 to 267 pounds. Complaints are attended to promptly and no inlet is allowed to remain in a dangerous condition for more than 24 hours, and in many instances is repaired in a few hours. The whole problem of street construction, particularly on car-track streets, loose rails, maintenance of footways, etc., is being investigated with a view to preventing accidents and consequent damage claims.

Fertilizing Value of Activated Sludge

Progress report of investigations made by the Sewerage Commission of the city of Milwaukee. Economic value as fertilizer greater than that of any other nitrogen-producing material.

As a supplement to the report of the Committee on Sewage Disposal of the American Society for Municipal Improvements and the Committee on Sludge of the American Public Health Association (the same report was submitted to both, the personnel of the two committees being largely the same, and was given in the November issue of PUBLIC WORKS), T. Chalkley Hatton read before the convention of the former society a supplementary report describing investigations being made by the Sewerage Commission of Milwaukee, of which he is chief engineer. The salient features are given below.

It is estimated that in 1925 Milwaukee will have about 3,000 tons of sewage sludge per month to dispose of, and if by investigation and experiment it can learn how to add $10 a ton to the market value of this, it will add $360,000 a year to its annual return therefrom. It has therefore devoted much study to the question of producing a marketable product and a demand for it. During 1922 it had activated sludge from its experimental plant applied to soil at two or three of the Wisconsin State experimental farms, by flower growers, landscape gardeners and owners of lawns. The Sewerage Commission created a Fellowship at the University of Wisconsin, to which O. J. Noer, a graduate of the Department of Soils of the College of Agriculture, was elected, and applied his entire time for about nine months in studying this subject.

The commission also became an associate member of the American Fertilizer Association and a substantial contributor to its Soil Improvement Committee, thus going into the matter from the viewpoint of the manufacturer introducing a new product to the possible consumer. When Mr. Hatton introduced the subject of using this sludge to the Fertilizer Association at its convention last June, he found them far from convinced that the material could be handled profitably, and it is hoped by working with them to develop a marketable material and a market for it. The questions asked at that convention convinced Mr. Hatton that unless the existing methods of investigating the subject were changed that goal would never be reached.

The typical activated sludge produced at the testing station of Milwaukee, when dried to about 10% moisture, contains between 6% and 7% total nitrogen, and from 2% to 2.5% of phosphoric acid. From 50% to 85% of the nitrogen is available, as determined by the alkaline permanganate method. Since the partially digested Imhoff tank sludge contains 1.5% to 2.0% nitrogen, 50% of which is available, and only a trace of phosphoric acid, it is evident how much more desirable it is to reduce the activated sludge to a commercial fertilizer basis.

Mr. Noer's investigations, in brief, have consisted of applying the sludge in different quantities upon different qualities of soils and with different plants, by itself and in different combinations with phosphoric acid, potash and lime, and comparing its effect with no fertilizer, commercial fertilizer, sheep manure, tankage, dry blood, cottonseed meal, fish scrap and ammonium sulphate, all of which are produced and sold for fertilizing purposes.

These investigations have embraced both pot cultures and farm planting, the soils used running through the various gradations from Ottawa quartz to heavy clay. They have also embraced quite extensively the development of turf upon fairways and grass upon greens of several golf courses.

These studies to date indicate that the economic value of the activated sludge is greater than that of any other nitrogen-producing material capable of being practicably applied to the soil.

As an example of this value, may be cited a comparison made between a 4:7:4 sodium mixture of 300 pounds per acre and a 4:7:4 sludge mixture, each containing 12 pounds of nitrogen. The first produced 7.9 bushel of rye per acre and the second 8.5 bushels per acre; the first cost $40 per ton and the sludge could be profitably sold for $20 per ton.

Taking another example in the application to corn plant; a 4:7:6 ammonium sulphate mixture applied at the rate of 1,000 pounds per acre produced 72 bushels, whereas a 4:7:6 sludge mixture produced 77 bushels per acre applied at the same rate. The soil without fertilizer produced 32 bushels per acre.

The reason for comparing the sludge with ammonium sulphate is that it is common practice among fertilizer manufacturers to obtain the nitrogen for their commercial fertilizer from this material, with which they have to mix a filler which adds no value to the mixture, whereas the sludge does add a valuable filler, adding, as it does, a humus to the soil. This last mentioned value is true of all types of sewage sludges.

Up to date one of the most successful uses for activated sludge has been for growing of grass upon lawn and golf courses. Numerous experiments have so far been conducted in comparison with barnyard manures, dried sheep manure and dried blood, the last three furnishing the required nitrogen in a mixed commercial fertilier containing 6:4:5, 6:3:3 or a 6:5:5 mixture. Sludge proved in all cases to be superior to sheep manure, although about one-third the price, and it compared favorably with dried blood. Several experiments on golf courses were and are being tried out where the sludge alone is being mixed in a compost with top soil, allowed to ferment for ten or twelve days and then broadcast over the surface of the greens or fairways. The results so far have been so marked as to gain the attention of some of the foremost consultant builders of golf courses, who are now watching these experiments closely.

When it is realized that nearly 3,000 golf courses are under construction in the United States in 1923 and all keepers of courses are looking for a cheap and satisfactory fertilizer particularly adapted to the growing of turf, it becomes important to prove to this market what sewage sludges may accomplish if scientifically prepared and applied.

The writer has no doubt that if sludge produced by the smaller cities was better prepared, it would find a ready market in the immediate vicinity, but those interested must educate the farmer and trucker as to its value, and this takes time and effort.

Sewage Treatment in Texas

In a recent report of the State Department of Health of Texas, figures and other data are given showing that of about 225 sewerage systems in that state, 205 are operating sewage disposal plants. The statement is made that this showing is largely due to efforts of the Bureau of Sanitary Engineering, which is endeavoring to secure complete enforcement of the provisions of the anti-stream pollution act, and have a sewage disposal plant installed in connection with every system in the state.

Repairing New York's Sewers

Many of the sewers in the Borough of Manhattan, New York City, have been in use for 50 to 70 years, and, as they were not all up to modern standards of construction, more or less distintegration is found taking place in them. It therefore becomes necessary that repairs and in some instances reconstruction be carried on more or less continuously. The report for the year 1922 contains a description of a method recently adopted in some of the repair work, the description being as follows:

"In the Fall of 1921 the sewer in 41st Street, between Madison Avenue and Fifth Avenue, was repaired by means of the cement gun. About 300 lineal feet of this sewer was repaired in this manner. Of this length, 30 feet of crown had fallen or had been removed in the process of repair, and at one or two places the entire crown had fallen in, leaving a hole 9 or 10 inches in diameter. All of the crown needed repointing. A coat of 1½-inch concrete was placed over the entire perimeter of the sewer above the flow line, with a greater thickness where a ring had fallen out.

"One year later—in the Fall of 1922—a careful examination was made and the entire work was found to be sound and hard, with no visible cracks; in fact, the sewer was as good as new, all joints having been pointed and an added thickness of arch constructed. From this test it is concluded that much use can be made of the cement gun method of repair on many of our old sewers at a considerable saving over other methods." This sewer was egg-shaped, 4 ft. by 2 ft. 8 in.

This work was considered so satisfactory that the city purchased a cement gun outfit and has this year been training a gang in the use of it and making further repairs. A sewer in Dey Street extending from Broadway westward, which was only 4 ft. by 3 ft., too small for a man to work in conveniently, was lined successfully, in spite of the additional trouble and inconvenience caused by the frequent discharge of hot water from boiler plants in adjacent buildings which made the temperature in the sewer almost unbearable. Owing to these unfavorable conditions, and the fact that the gang was unaccustomed to the use of the equipment, figures as to cost, rate at which the work was done, etc., were not considered important. However, it is believed that in connection with other work of this nature now planned accurate records will be kept and such figures will be available for work done in the future.

One great advantage attached to repairing in this way in large cities is that there is practically no inconvenience to traffic, as the street is not torn up and the only encumbrance is that of the machine that is installed on the surface of the street at the manhole.

Biology of Sewage Plants

The State Department of Health of New Jersey has for some months been conducting a series of investigations of the operation of sewage treatment plants, especially with reference to the biology of the processes going on therein. This latter work is in charge of Dr. Willem Rudolfs. The Imhoff tank and sprinkling filter plant at Greenbrook Park, N. J., is that where most of the investigations are conducted. These investigations were begun in 1921 and considerable information has already been obtained and studied, but the investigators feel that their work has only begun. Some of the results have already been noted in PUBLIC WORKS, and others will be in the future as they are developed.

A recent statement by Dr. Rudolfs gives certain tentative conclusions, the significance of which has not yet fully been determined. The following are some of the more interesting of these:

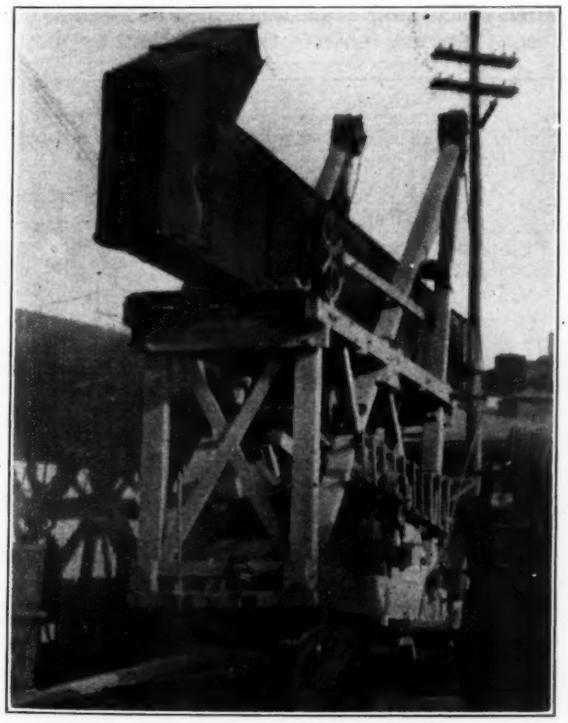
A study was made of the bacterial groups which digest protein, those responsible for sulphur reductions and oxidations, nitrogen transformations and the destruction of cellulose. During the winter months the bacterial population of the Imhoff tank and sprinkling filter was found to be similar, the predominating organisms in each being the proteolytic bacteria and those transforming nitrogen, while those responsible for sulphur changes were less abundant and the cellulose destroyers still less. In general, the nitrogen oxidizers were abundant at first and then decreased during the winter months, while the nitrogen reducers increased at the same time.

Concerning the lower animals, several interesting conditions were found. The free moving forms, such as the free swimming ciliates and worms, increase in number as the film on the stones builds up, and intermittently pass out in the filter effluent along with the film. It is significant that just before the film passes out the worms begin to increase, and it is thought probable that the worms in their continuous migrations through the film not only render it more porous, but help to loosen it and thus accelerate the purging of the filter. Following this, the growth of opercularia (the stalked.

fixed protozoan form) increases greatly and may be important in the functioning of the filter.

The botanical studies showed that algae were the predominating flora on the surface of the filter bed, while fungi were much less abundant, this relationship continuing throughout the year. Below the surface, filamentous bacteria such as beggiatoa alba, which use sulphur for energy, were found constantly throughout the year, appearing with more regularity than any of the fungi. Common fungi, largely molds, were found in the subsurface. There appeared to be a seasonal change in the growth and development of certain fungi found in the filter beds. Penicillium did not make its appearance during the summer months, but was rather abundant during the fall, winter and early spring. Water molds appeared at irregular intervals, chiefly during the late winter and spring.

Chemical studies were made with two objects, (one) to find possibly chemical correlation between the bacteriological, zoological and botanical studies and, (two) to secure data for improving the operation of existing plants. The chemical work will become increasingly interesting and difficult when the excretion products of bacteria, microscopic plants and animals are studied in detail. Among results already obtained by chemical studies, it has been found that the greater part of the effective nitrification in sprinkling filter beds takes place at the bottom of the bed throughout the year, and it is believed that old solids which collect at the bottom offer a large active surface to the sewage flowing through them and so are responsible for this nitrification.



PORTABLE ELECTRIC ELEVATOR FOR CLEANING SETTLING CHAMBER IN SEWER.

Fly Nuisance at Disposal Plants

An article on the above subject by Paul Keim has been published in the "Techniches Gemeindeblatt," translated and abstracted by Abel Wolman, and the abstract appears in the "Engineering Abstracts" published by the Bureau of Public Health. In this a presentation is given of the information available concerning the more common fly and insect species associated with sewage disposal plants, and a discussion of their significance in the production and transmission of disease, the author giving detailed descriptions of psychoda, phlebotomus and chironomus groups.

The author concluded from his investigations: "In contrast with other places, disposal plants do not offer satisfactory breeding grounds for house and stable flies. To a much greater degree do they provide the special living conditions for adaptable diptera. These animals cling to their breeding grounds, reach only passively, through wind transportation, clothes or nearby houses and are entirely harmless. They have no significance as transmitters of disease or as parasites and represent no hygienic danger."

Portable Elevator for Sewer Settling Chamber

A specially designed, electrically operated portable elevator has recently been put into service for cleaning the settling chamber of the Division Street sewer in San Francisco. The elevator is carried on a 4-wheeled wagon and, when ready to be used, is lowered by a hoist operated by the same electric motor that operates the elevator. With the bottom of the elevator at the bottom of the settling chamber, men there shovel the material directly into the elevator and this delivers it into bottom-dump wagons. It is said that 28 cubic yards of deposit can be removed in a day with this elevator, whereas with the old hand method 4 cubic yards was the average.

Large Railroad Terminal in Dallas

The Santa Fe Railway Company is constructing in Dallas, Texas, a terminal project consisting of a building for office and warehouse purposes, with underground unloading tracks. The building will be constructed in four units separated by intersecting streets, one unit being twenty stories and a basement high and the other three units ten stories and a basement high. It will cost approximately $3,500,000. Excavation is nearly completed and concrete has been poured for foundations of two units.

One of the features of interest to paving engineers is that the floors, which approximate 1,000,000 square feet in area, will be laid with Uvalde rock asphalt, the thickness varying from ¾-inch to 1½-inches, the contract having been awarded to the Uvalde Paving Company of Dallas. This is said to be the largest contract for mastic flooring ever made. The material used is a lime rock located in Uvalde County about 100 miles west of San Antonio.

China Basin Terminal

Pre-cast concrete caissons connected by curved curtain walls, foundation excavated by use of dynamite and supported on piles, form combined sea wall and wharf.

By Charles W. Geiger

The most important project undertaken for many years by the California State Harbor Commission is the China Basin Terminal, the substructure of which is now nearing completion.

The contract for the substructure (which is being carried out by the Healy-Tibbets Construction Company) includes the construction of a main seawall; a wing wall; the filling of the area inside this seawall; and the construction of foundations for the terminal building and of a wharf.

The main seawall is of a type which has not previously been used in San Francisco. It consists essentially of a series of pre-cast reinforced concrete caissons which are set approximately 15 feet apart in the clear (22 ft. center to center), the space between adjacent caissons being closed with pre-cast curved curtain walls. The caissons are 7.5 feet in width, 20 feet at right angles to the axis of the wall and from 54 to 57 feet deep below the level of the deck.

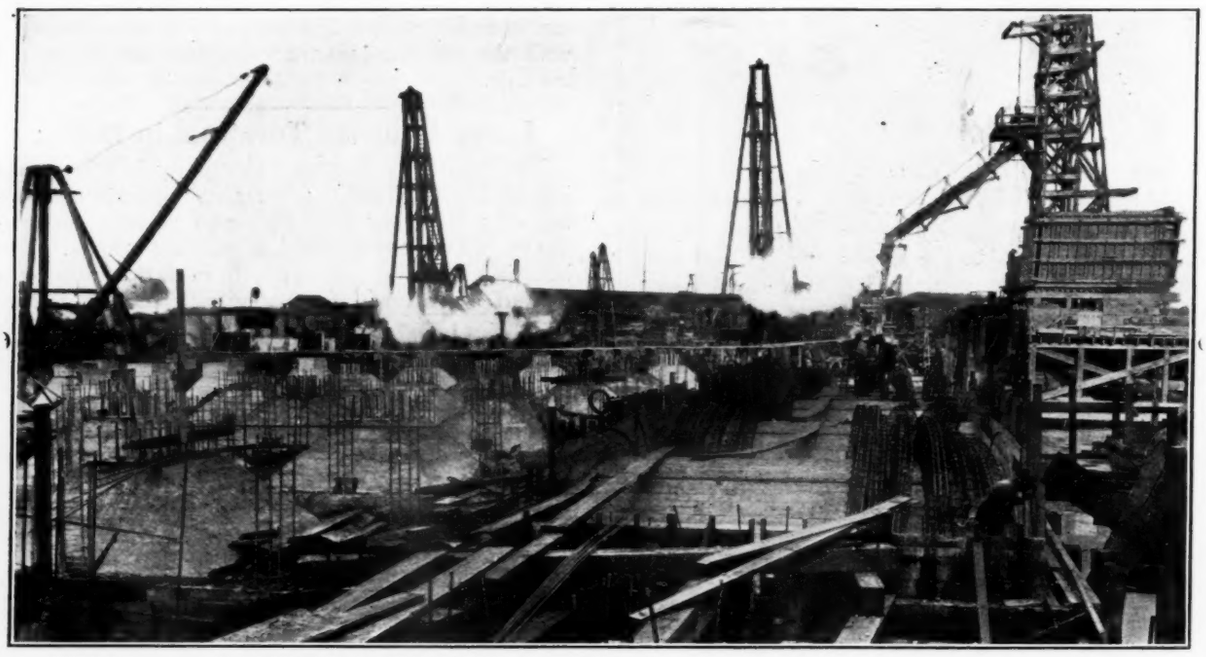
The harbor board permitted the contractor to use an area along the China Basin seawall south of the China Basin wharf for casting, handling and launching the caissons. The caissons were built with three compartments with one end cast solid. Extra precautions were taken to insure an impermeable concrete so that, with the ends of the caissons bulkheaded, they would be water tight and could be floated to place. They were not handled for at least 28 days after pouring.

Forty caissons were used in the entire seawall. They were launched on greased ways and towed to the point where they were to be used by means of a motor boat.

A falsework was built out over the line of the caissons, which carried three steel rails, over which ran a traveler with flanged wheels, which was used in setting the caissons.

In setting the caissons, an excavation was made in the hard bottom by the use of dynamite, which was not more than 4 feet wider than the caisson at any point. In using the dynamite, a charge was placed in a weighted pipe, which was supported by a pile driver derrick, and a time fuse lighted. The pipe was then dropped into the water and the end forced into the hard bottom, when the dynamite exploded. The loosened material was removed with a clam-shell bucket. The excavation was then leveled up to the exact bottom elevation, using crushed rock. By means of a pump on a pile driver derrick, water was pumped into one cell of the caisson (through a hole in the bulkhead) to start it sinking and at the same time it was revolved into the right position with the major axis normal to the line of the wall. Water was then pumped into all the compartments of the caisson and it was lowered by the traveler running on the falsework onto the prepared bed, where it was held in place by means of bracing at the top and crushed rock deposited in the excavation at the bottom.

When the caisson was in position, the wooden bulkhead was removed and the bottom concrete bulkhtad knocked out by means of a steel shaft about 20 feet long and 6 inches in diameter with a chisel-pointed end, which was dropped by a pile driver derrick. After the bottom had been battered out, from 15 to 18 piles were driven in the bottom of the caisson, after which the caisson was sealed to a height of 12 feet with tremie concrete, this being done by means of



GENERAL VIEW OF WORK ON CHINA BASIN TERMINAL.
Concrete footings at left. In background, driving piles for footings. At right, concrete plant and forms and reinforcement for arches that carry wharf.

a special carrier on flanged wheels running on steel rails on the caisson falsework. The tremie was water tight and sufficiently large to permit a free flow of concrete. The concrete was mixed on a barge which could be moved along the line of caissons as the work progressed. After the tremie concrete had properly set, the caisson was pumped out and all laitance cleaned from the surface of the under-water concrete, after which the caisson was filled with concrete to its top.

The curtain walls closing the spaces between the caissons are curved so as to act as arches. They were pre-cast of Class A concrete, the forms being set so that the arches stood vertical during casting, and each arch being provided with U bolts for handling and placing. They were not handled until at least 28 days after pouring.

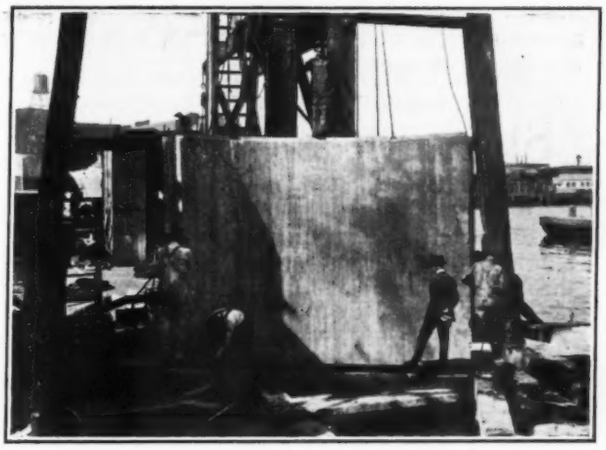
The arches were set by lowering them between adjacent caissons. When they were in place and properly jointed, rock was carefully placed on both sides. After the rock was in place to the proper height, the joints between the arches and caissons were grouted with 1:2 mortar. In placing the grouting, a canvas stocking was slipped over the grout pipe, which was then lowered to the bottom of the groove at one end of a caisson. The grout was then poured through this pipe, which was withdrawn, leaving the grout in the canvas bag making a tight seal.

The caissons and arches serve two purposes—acting as a seawall and supporting a wharf carrying railroad tracks. This wharf will be 1000 feet long and the construction will permit of dredging to a depth of 36 feet at mean low tide.

The wharf and railroad tracks are supported on a series of reinforced concrete arches which in turn rest on the caissons. In pouring them, that portion over the caisson and up to construction joints approximately four feet on each side of the crown, was poured and allowed to set for seven days, after which the crown or key section was poured. The spandrel wall sections on both sides, the cantilever slab extension on the water side, and the curtain arch closures on the land side, were then constructed. The five caissons on the east end are tied together with heavy concrete girders on both sides to take care of the unbalanced thrust of the last arch.

Approximately 200,000 cubic yards of sand was deposited as fill in the area behind the seawall, a depth of 42 to 45 feet over the area covered by the terminal. The filling along the caissons was subsequent to the rock fill work on both sides of the wall and was not carried more than 15 feet above the hard bottom until the pile foundations for the buildings had been driven and the caissons tied back to them.

The sand fill in the area back of the seawall accomplished three things; it protected the foundation piles from marine borers, gave the piles lateral support, and carried a portion of the first floor of the terminal, thus saving the cost of a supported floor under this area of the building. The first floor over the outer half of the building is of flat slab construction and is supported by the column footings. The inner portion of the floor is to be laid directly on the sand fill.

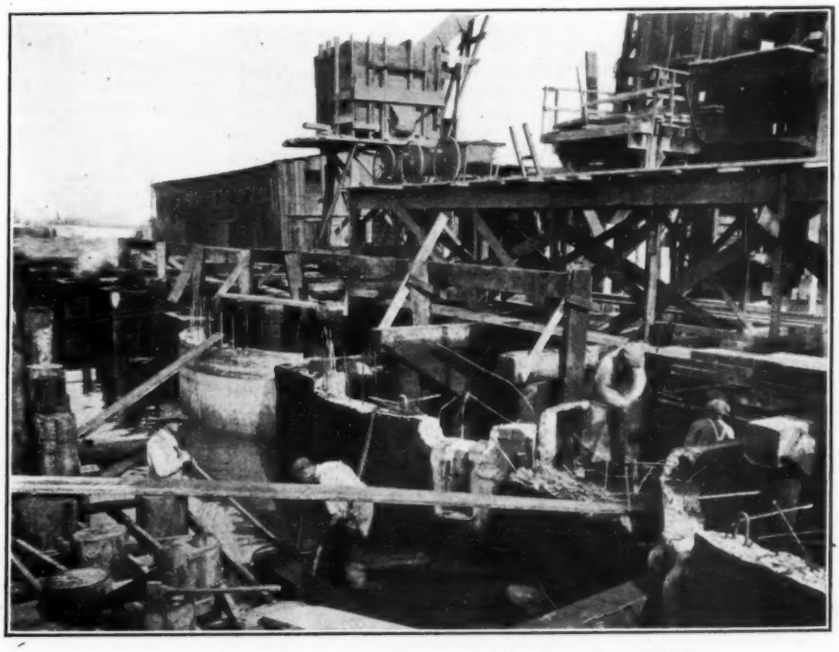


PLACING A CURTAIN WALL ARCH IN POSITION.

The building which this superstructure will support will serve as a combined transit shed and warehouse, 812 feet in length and six stories in height. The cost of the substructure will be about $950,000 and of the entire terminal approximately $2,300,000.

This will be the first multiple story warehouse on the Pacific Coast, if not in the United States, located immediately adjacent to deep water, with a berth which will permit of docking large ocean steamships.

It will bring to the port of San Francisco the facilities for handling at waterside all cargoes of



TOPS OF CAISSONS AND CURTAIN WALL ARCHES.

seasonable freight, grain, cotton and the tropical pineapple and sugar, at a minimum cost for both domestic and export movement.

Strength of Concrete

Relations between compressive strength of concrete and the cement and voids therein. From investigation at University of Illinois.

Under the title "The Strength of Concrete: Its Relation to the Cement Aggregates and Water," the Engineering Experiment Station of the University of Illinois has published a bulletin that "enunciates relations between the compressive strength of the concrete and the amount of the cement and voids contained therein. It develops methods for studying the concrete-making properties of fine and coarse aggregates and for the comparison and acceptance of aggregates. It outlines means for designing concrete mixtures for different densities and strengths when the voids in mortars made up with a given cement and fine aggregate have been determined by laboratory tests." This bulletin is credited to Professors Arthur N. Talbot and Frank E. Richart as authors.

In 116 pages of text, tables and diagrams it discusses the subject under the headings "Materials, Methods of Testing, and Tests," "Concrete with Regularly Graded Aggregate," "Mortar Voids and Water Content," "Concretes at Basic Water Content," "Concretes with Varied Water Content," "General Discussion," and "Applications to Proportioning of Concrete Mixtures." The "Conclusion" is as follows:

Comments.—The combination of the mortar-voids tests, the analytical relations of cement, aggregates, voids and water, and the experimental determination of strengths, by the methods outlined in this bulletin, offers a useful method for the study of materials, the design of concretes, the calculation of quantities, the comparison of mixtures, and the estimation of strength.

The mortar-voids test takes account of the factors which give uncertainty to the sieve-analysis function. If the requirements for structural strength and surface adhesibility be otherwise guarded, it will enable new or untried materials to be judged. It will permit easy comparison of aggregates. It is of interest in showing what range of mortar richness will produce the best results with a given fine aggregate and thus in aiding to find conditions under which the use of what may have been thought to be a poor aggregate can be permitted.

The design and estimation of strength of mixtures may be made for a given amount of cement, for a given limit of quantity of coarse aggregate or any smaller value, or for a given ratio of cement and sand. A reduction curve may be obtained for finding the relative strengths for different relative water contents, based on the basic water content, that giving the minimum volume of the mortar and concrete.

The use of the absolute volume of the materials gives simple and convenient methods of analysis and calculation, and in many ways is advantageous. To think in terms of the absolute volume of the materials in a unit of volume of mortar or concrete itself gives an advantage in making comparisons and judging effects. When the density of the material as it is found by the method of measurement to be used on the work is known, the volumes by bulk measurement may easily be obtained. The advantage of measuring aggregates by weight, in producing concrete of uniform quality, is apparent. Since the specific gravity of sands in a given locality varies but little, the use of an average specific gravity is sufficiently accurate for most purposes.

The method of treatment brings out the old principle that other things being similar the strength of the concrete is equal to the strength of the mortar of the concrete. "Other things" refers to the water content, to the degree of compactness, to the conditions of storage, etc. Limitations in such matters as amount of coarse aggregate may be expected to come within ordinary practice in well-made concrete.

It should be noted again that the equation for strength of concrete in terms of the voids-cement ratio or cement-space ratio will be dependent upon the quality of the cement, and that some variation in the constants of the equations may be expected. The tests were made at an age of 28 days, but equations of the same general form for strength at other ages may be determined from experimental data.

The matter of allowance for the water absorbed by the coarse aggregate during the period of placing and setting will need careful attention in so far as this affects the amount of water left to be counted as mixing water. Any water carried into the mixture on the surface of the particles of the coarse aggregate and not absorbed by the aggregate during the period of mixing and placing will, by the technique described for the tests, be included in the amount considered as mixing water.

Further study and experience will doubtless develop limitations and suggest modifications and standardization of methods. To what extent and in what way account should be taken of the possibility that the sum of the volume of the mortar and the coarse aggregate may not reach unity, is one question. What limit to the volume of the coarse aggregate may best be used for different aggregates, different water contents, and different kinds of construction, may well be studied. The shrinkage of wet mixtures and rich mixtures needs consideration. The effect of air voids upon the strength of concrete, and also the effect of the absorption of water by the aggregates during and after the setting of the cement, should be studied. The effect upon strength of the addition of water beyond basic water content for a variety of fine aggregates is worthy of experimentation and study, as well as methods of allowing for the reduction in strength accompanying an increase in water content. These and other topics deserve to be taken up by a number of research laboratories and given careful study, regardless of whether the methods outlined in this bulletin are considered the most satisfactory for the study of the designing, comparison, and determination of quantities for concretes.

Résumé of Method.—In review of the steps to be taken in the application of the methods outlined in this bulletin, the following is presented:

(1) The mortar-voids curve is determined experimentally. For certain purposes the use of a general mortar-voids curve of materials having the same characteristics may be sufficiently accurate. Mortar-voids curves may well be made up for two or more water contents.

(2) Curves giving the water content, cement content, and ratio of voids to cement for varying ratios of fine aggregate to cement may be made up from the data of the mortar-voids test.

(3) An equation or a diagram giving the relation between the strength of mortar and concrete at a given age for the common run of cements should be available, as should a reduction curve for the effect of relative water content.

(4) The limiting value should be known or judged for the absolute volume of the coarse aggregate that may be used under the conditions of placing and tamping obtaining on the work.

(5) For use in making measurements by bulk, the density of the fine aggregate and the coarse aggregate for the method of measurement to be used on the work should be known.

(6) With such information the use of the analytical relations given by the equations will permit designs, comparisons, and estimates of strength and quantities of materials to be made.

It is felt that the method of attack outlined in this bulletin will be helpful in the work of analyzing, comprehending, and judging the effects of the various elements entering into the strength properties of concrete, as well as in many applications to the problems of practice.

Birmingham Waste Utilization

Birmingham, England, is now disposing of its organic wastes by what is known as the "Iwel dry process system." There are nine melters and dryers, which are steam jacketed, cylindrical vessels in which the material under treatment is broken up and forced in thin layers against the hot plates of the vessel by means of beaters bolted on to a central shaft. Live steam does not come into contact with the material, and therefore the available protein is conserved and the natural properties of the fat retained and the loss of glycerine avoided. From ½ to ¾ of a ton is placed in the vessel at a time. It is maintained at a temperature of 90 degrees for about 4½ hours, which results in the complete destruction of bovine tuberculosis bacilli. All of the abattoir, market and trade refuse is treated at this plant amounting to over 3,000 tons a year.

All the tin cans collected are treated at a detinning plant, the cans being immersed in an electrolytic bath of sodium hydroxide and tin chloride for thirty minutes. Tin is deposited on the cathode of about 77% purity. The current used amounts to 25 kwh. per ton of tin cans.

Garbage Collection in Los Angeles

The City Engineering Department of Los Angeles has prepared, from the data recorded concerning garbage collection and disposal in the city since 1914, a chart showing cost items of the various services connected with this branch of the city engineer's duties.

From this it appears that the maximum amount collected per man for any one month was 79.3 tons in July, 1921, and the minimum was 30.8 tons in November, 1918. The amount collected per day averaged 101.5 tons at the beginning of the record and had increased to 185.2 tons in August, 1916, but during the war fell to 102.5 tons. After the war it again increased and reached a maximum of 381.2 tons in August, 1923, which is equivalent to about 0.6 pound per capita per day.

Figures for the cost of collection show that this has varied from $2.33 per ton in July, 1919, to $5.36 in April, 1920, while in May, 1923 (the latest figure given), the cost was $3.96. The city receives 60c. per ton from the hog raisers for the garbage, reducing the cost to $3.36 in May of this year.

The Board of Public Works is preparing plans for a municipal incinerator to take the place of the sale of garbage for hog raising, believing that this would prove more sanitary for garbage disposal and less costly to the city.

Concrete Roads in 1923

In a review of the economic outlook, Herbert Hoover stated a few days ago that there had been a shift from public to private construction in 1923 as compared to 1922, along various lines, especially those of building construction. One indication cited was the fact that concrete road contracts last year were about 16% less than in 1922, although the output of cement had increased 20%.

Lateral Earth Pressures

Conclusions from experiments at the University of Cincinnati. Poncelet theory considered reliable.

Experiments on lateral earth pressures covering two years formed the basis of a paper presented to the American Society of Civil Engineers last year by Jacob Feld, who was assigned this subject as a Baldwin Fellow in Civil Engineering at the University of Cincinnati. This paper has been assigned the Collingwood prize for 1923.

The apparatus was designed to measure directly, by means of platform scales, the components of the active pressure on a model wall 6 ft. high and 5 ft. wide, the only restraints on the wall being the measuring devices. The experiment and discussion of the data are described in 58 pages of the "Proceedings" of the society for April. A brief synopsis and summary of the conclusions are given below:

Tests with sand under various conditions, using vertical and battered walls backed with wood, glass, and sheet iron, indicate the reliability of the Poncelet theory of the maximum wedge causing oblique pressure. Tests with walls battered in both directions show that the direction of the resultant pressure is always inclined to the normal at an angle equal to the angle of friction on the back of the wall. The effect of surcharge does not agree with the ordinary theoretical assumptions. Settling and variations in temperature cause remarkable changes in the lateral pressure.

General conclusions, deduced from these experiments, using sand for fill, are given by the author as follows:

1. The fill does not act like a liquid. The transmission of pressure does not obey the Pascal law.
2. The fill does not act like an elastic solid. Loads on the fill cause a change in physical properties as well as a deformation. These changes slowly disappear, but not according to any definite law.
3. There is no sharply defined wedge of rupture, nor can any surface of rupture be detected on the surface of the fill. However, loads on the fill beyond the wedge of rupture have practically no effect on the lateral pressure. Loads on the wedge of rupture do not increase the pressure by as much as would be required by a well-defined and distinct wedge.
4. The lateral earth pressure, for all types and kinds of wall and for all types of loading and fill, acts at an agle to the normal to the wall equal to the angle of static friction between the fill and the back of the wall. The height of application is above the 1/3 point, but below 4/10 point of the height.
5. For a vertical wall with horizontal fill, the value of the horizontal pressure is given by the formula, $E = \frac{1}{2}\, y\, h^2 \tan^2 \frac{1}{2}\,(90° - P)$, in which P is the angle of internal resistance of the fill, corresponding to the static friction of the filling material on itself. This formula is a special case of both the Rankine and Coulomb theories. The value of the vertical component is easily determined from a consideration of Conclusion 4.

6. For all general cases, the pressure is obtained closest by the general wedge theory

$$E = \tfrac{1}{2}\, y\, h^2 C; \qquad C = \left(\frac{\cos\,(P - a}{(n+1)\cos a}\right)^2 \frac{1}{\cos\,(P^1 + a)}$$

$$H = E\cos\,(P^1 + a);\; n = \sqrt{\frac{\sin\,(P + P^1)\sin\,(P - e)}{\cos\,(P^1 + a)\cos\,(a - e)}}$$

in which E equals total theoretical earth pressure; H equals horizontal component; P equals angle of natural slope or repose; P^1 equals angle of friction between wall and fill; a equals angle between the vertical through the toe and the back of the wall, being negative if the top of the wall overhangs the toe; e equals angle between the free earth surface and the horizontal, being negative if the surface is below the horizontal; h equals height of fill, measured vertically, and y equals weight of fill, in pounds per cubic foot.

The wedge theory that disregards wall friction gives too high results except for a vertical wall, in which case it gives results closer to the experimental results than the general wedge theory.

7. The general wedge theory gives low results for a vertical wall and it is better to use the wedge theory, disregarding the wall friction,

$$H = \tfrac{1}{2}\, y\, h^2 N; \quad N = \left(\frac{\cos\,(P - a)}{(n+1)\cos a}\right)^2 \frac{1}{\cos a}$$

$$E = H\sec P; \qquad n = \sqrt{\frac{\sin P\sin\,(P - e)}{\cos a\cos\,(a - e)}}$$

8. The experimental results are not in agreement with the Rankine theory except as noted in Conclusion 5.

9. The effect of settling is to increase the pressure exerted by the fill, the maximum being attained within two hours of placing the fill. The pressure then decreases to the minimum within 24 hours, after which the pressure oscillates toward equilibrium between the maximum and minimum thus found.

10. The pressure is a direct function of the temperature.

11. The pressure is only slightly affected by humidity, except that in dry weather evaporation of moisture from the fill along the wall, near the surface causes a greater horizontal and less vertical component.

12. Surcharges, both static and dynamic, compress the fill and increase the resultant pressure. Such an increase disappears in time, usually in about seven days.

SUMMARY

From the Cincinnati experiments, together with the results of other experiments, the writer recommends the following rules for the determination of the lateral active earth pressure, to be used in the design of retaining walls and similar structures.

1. The resultant pressure is inclined to the wall, deviating from the normal by an angle equal to the angle of friction between the fill and the wall.

2.—The resultant acts above the third point, and, for a heavy surcharge, as high as the 4/10 point.

3.—The amount of the horizontal component is given closest by the wedge theory, taking as the angle, P, the experimentally determined angle of internal resistance of the fill.

The effect of surcharge, temperature, settling, etc., is found at the end of the Cincinnati tests report.

Rural Distribution Systems for Electricity

Ontario Hydro Commission uses cables laid in 18-inch trenches, finding them cheaper and generally more satisfactory.

It has been the common practice of the Hydro-Electric Power Commission of Ontario to carry its rural distributing circuits on poles, as has been the practice in this country also. In 1921, however, owing to the great increase in cost of labor and material, the Commission's engineers investigated the possibility of underground construction in rural districts. The use of cables laid underground is of course a well-established practice and, in fact, antedated the use of pole lines. The application of underground cables to the rural service is, however, quite new and the methods of installation and the details of design were given considerable study. More than 150 miles of cable has already been laid underground by the Commission and is operating successfully. The construction employed is described as follows in the bulletins of the Commission by A. G. Lang, distribution engineer for the Commission:

The standard cable is briefly described as follows:

Single conductor, No. 6 B. & S. gauge, 7 strand copper, insulated with 30% para rubber 3/32 inch in thickness, laid over with a rubber filled insulating tape and covered over all with a pure lead sheath, 1/16 inch thick.

This cable is furnished in uniform lengths of 1/3 mile each.

The cable is laid in a trench at a depth of from 12 to 18 inches and is not protected by a duct or covering other than the re-filled soil, except at hazardous locations such as road crossings, where a creosoted plank is placed above the cable after a few inches of the excavated soil has been re-filled.

The trench is made by a grading plough, of exceptional strength, drawn by a caterpillar tractor. The plough is designed to turn a furrow 18 inches in depth. It is fitted with a heavy coulter which readily cuts through tree roots 4 inches in diameter.

The tractor is also used to draw a carriage on which the cable reel is mounted and from which the cable is laid in the trench with a minimum of handling. The tractor is also used to draw a scraper for re-filling the trench.

Cable joints are enclosed in lead sleeves, compound filled, and sealed with wiped joints to the cable sheath.

At points where service to consumer is required, a wood pole is set and the cable is carried up the pole, terminating in a disconnecting pothead; continuing the circuit along the highway, the cable is carried down the pole again from a second pothead. This method eliminates the necessity of a joint at the foot of the pole and the disconnecting potheads form a convenient means of opening the circuit for test or other purposes.

The potheads are installed with wiped joints. The cable on the side of the pole is protected by a metal moulding. On this pole the service transformer is mounted and the secondary service wires are usually run overhead to the consumer's premises.

In operation the cable, up to this date, has proved quite satisfactory. Occasional faults have developed but comparatively few considering the total mileage in operation. Novel methods have been devised for finding faults and the locating and repair of same is now accomplished quickly and satisfactorily.

It should be stated that this type of construction is not expected to supplant entirely the use of overhead construction, and the local conditions will govern the decision in making a choice between the two types.

Under conditions favorable to the installation of the cable the capital cost per mile will be less than for an overhead line. This applies to single phase circuits only, where in general the lead sheath is used as the grounded conductor of the circuit. Excepting under conditions extremely unfavorable to overhead construction the cost of laying 3-phase circuits underground will exceed the cost of similar circuit overhead.

It is expected, however, that the cost of maintenance and operation and the rate of depreciation will be decidedly in favor of the underground system.

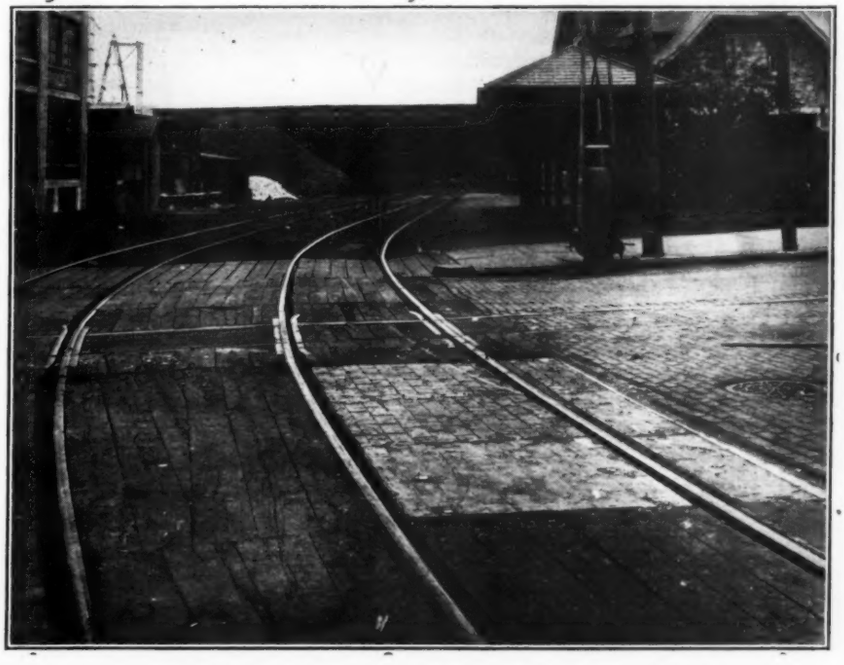
The underground system is proving very popular by reason of the elimination of unsightly wood pole lines from the highways, the avoidance of the necessity of cutting shade trees and the satisfactory operation during storms when overhead lines may occasionally be out of commission for considerable periods.

Rubber Pavements

History during past eighty years. First street pavement in United States laid at railroad crossing in Racine last September.

What is believed to be the first street pavement made of rubber to be laid in the United States was placed in Racine, Winconsin, on the direct highway between Chicago and Milwaukee where it crosses the Chicago, Milwaukee and St. Paul Railroad, on September 16th of this year. It has been the practice of the railroad company to use 6x12 hard wood planking at this crossing, and it was necessary to replace the planking three or four times a year. It is hoped that the rubber will be found much more durable.

This pavement is constructed of rubber blocks 2 inches thick, 4½ inches wide and 12 inches long fastened with cement and nails to 4x6 creosoted planks bolted together with half-inch bolts into sections 5 feet long. Each section is lag-screwed to the ties beneath and can be removed if necessary to repair the ties or the track. The rubber blocks are made of old automobile tires ground up, properly compounded and molded under high pressure. They are an adaptation of the patented Wright rubber floor tiles, being provided with flaps or extensions of the tile of about half the thickness thereof, which extensions or flaps are provided with countersunk holes through which screws are driven to fasten each block to the wooden base in addition to cementing it thereon, the screw heads thus being covered by the overlapping of the adjacent tile. These blocks are manufactured



RUBBER PAVEMENT AT RAILROAD CROSSING.
Most of the crossing is still of planks, which have been used during the past.

by the Wright Rubber Products Company of Racine.

In England, and to a certain extent in certain other countries, trials have been made of rubber pavement with more or less success. The first chief claim for such pavement is its durability. A rubber floor in one of the busiest banks in London after twenty years' use shows practically no wear, while the adjacent stone had so worn down that the rubber had to be pared down to a level with it. In addition to durability, there is resilience and noiselessness, although these two are not so important as they were before the days of pneumatic tires.

Perhaps the first patent for rubber paving was obtained in England in 1843 by William Freeman, and about this time rubber pavement was laid in a courtyard in Manchester. In 1876 the Midland Railway Company contracted with Charles Macintosh and Company to lay large sheets of rubber on one side of its station to lessen the noise and tremor of vehicles. This pavement carried traffic for thirty years before renewal. A similar pavement was put down by the same firm in 1881 at a cost of $32.70 a square yard, part of which was in excellent condition twenty-two years later although some of it had to be replaced. In 1904 the courtyard of the Savoy Hotel, London, was paved with rubber by the same firm at a cost of $40.78 a square yard not including the concrete foundation. This showed some wear at places due to the stopping and starting of vehicles, especially those with studded tires, while oil dropping from motor cars had weakened certain spots.

In 1913 rubber-capped wooden blocks, patented by M. M. Dessau, were laid at the junction of the new and old Kent Roads, one of the most crowded corners of London. The blocks consisted of Jarrah wood, into the upper surface of which rubber caps ½-inch thick were dovetailed. The blocks were grouted in asphalt and rubber keys placed between them. After 295 days of traffic that averaged 190 tons a square yard per day, the rubber had not worn noticeably, whereas an adjacent wood block pavement carrying similar traffic had lost half an inch. There had been no skidding or slipping on the rubber. It was found, however, that there was a wear of both rubber cap and the top surface of the wood block where the two were in contact. In 1918 George Anderson invented a block consisting of a half-inch of gray rubber placed on a layer of vulcanite held closely to a steel plate with circular perforations into which the vulcanite had been pressed, the edges of the steel plate being turned down to form lugs which were imbedded in the concrete foundation. A section of this pavement was laid in 1920, but after a few months it was found that 15% of the rubber blocks had separated from their plates. Consequently a new plate was tried of expanded metal imbedded in the rubber. The new plates seemed to hold the rubber satisfactorily. However, the pavement did not hold up well in the long run and the experiment was abandoned.

In 1913 Phillip Schidrowitz, a rubber chemist, was consulted concerning the cost and practicability of rubber pavements, and figured that as a ton of rubber composition paving material would cost $484 as compared to about one-quarter of this cost for asphalt, he feared that rubber paving was not practicable, even conceding superior durability and other merits.

The latest rubber paving to be actually laid in London was used in 1923 for repairing a strip of roadway in Borough High Street, Southwark. This consists of solid rubber blocks grooved at the sides and laid on the same kind of foundation as the standard wood paving block, an application of pitch being made at the sides and ends. The blocks weigh 4 pounds 9 ounces each and are the same size as the ordinary wood blocks. A better quality of rubber is used in the wearing surface than in the base.

E. F. Sperrell, surveyor of Holborn Borough, London, announced in 1923 that the Council of that Borough was intending to experiment with a rubber pavement made of concrete blocks to which quarter-inch rubber pads would be directly affixed. Such a pavement is to be given a six-months' test on a section of Upper St. Martin's Lane. The cost is estimated at about $14 a square yard as compared to $8 for wood block, but it was expected that the rubber would last 25 years or more, while wood block lasts 12 or 14 years.

Some experimenters are endeavoring to devise a method of spreading rubber in a liquid or semi-plastic state, as is done in laying bituminous pavements, but the difficulty appears to be finding some method of so fastening the rubber to the base that the traction exerted by heavy vehicles will not tear it loose. Others believe that, with the passing of metal-tired vehicles, a rubber roadway has lost much of its advantage over other materials, but that there is a real need for rubber sidewalks.

Asphalt Pavements in 1923

The U. S. Geological Survey Report for 1922 states that 2,446,024 short tons of asphalt were used in this country during that year, of which 2,047,308 tons were recovered from petroleum and 122,929 tons were imported lake asphalt. Domestic rock asphalt is reported as 298,047 tons, but of this only about 30,000 tons was actual asphalt.

In discussing these figures, J. E. Pennybacker, general manager of the Asphalt Association, states that, of the above amount, about 845,933 tons of asphalt were used for paving. Also he states that, while the paving tonnage for 1923 is not yet known, figures compiled indicate an excess of 20 per cent. over 1922. This would give a total of 1,140,000 tons, equivalent to 114,000,000 square yards of pavement. Allowing 10 per cent. for maintenance leaves 102,000,000 square yards of new construction and resurfacing.

This includes both city streets and highways. Figures for 290 leading cities last year showed that about 42 per cent. of the mileage of their street

pavements was of asphaltic type. Also a considerable yardage was in the form of "black base," more than 15,000,000 square yards of which is now in service in the five Pacific Coast states. But even with black base and city streets deducted there would probably be nearly 90,000,000 square yards of highway pavement of asphaltic type laid last year.

Concrete Pavements in 1923

During 1923 approximately 74,000,000 square yards of concrete pavement was laid, according to the Portland Cement Association. This is about 20 per cent. more than the record for 1922. Nearly half of the total, or about 36,000,000 square yards, was uncompleted 1922 contracts; while 32,000,000 square yards of the 1923 contracts remain to be completed this year. The outstanding accomplishment of the year was the construction of 1,000 miles of concrete highway by a single state—Illinois.

Canadian Highways

Figures for Canadian highways for the year 1922-23, recently made public by A. W. Campell, chief commissioner of highways for the Dominion government, show 112 projects approved, covering 1,207 miles, and with an estimated total cost of $9,265,055, of which the Dominion contributes $3,706,022. The cost per mile for each of the several provinces averages as follows: Ontario, $34,252; British Columbia, $23,918; Quebec, $10,841; Nova Scotia, $5,730; Manitoba, $3,895; Prince Edward Island, $2,719; Saskatchewan, $2,199.

Structural Design of Highways

Digest of Report of Committee of Advisory Board on Highway Research of the National Research Council.

At the meeting on November 8 and 9 of the Advisory Board on Highway Research of the National Research Council the Committee on Structural Design of Highways, the chairman of which is A. T. Goldbeck of the U. S. Bureau of Public Roads, submitted a very interesting report, of which the following is a digest:

1. Subgrade

A layer of sand, cinders, broken stone or other porous material will prevent capillary moisture from rising to the overlying road surface. Tile drains are inefficient in removing capillary moisture.

Results of tensile, shear and compression strength tests on various soils are given in detail in the report.

A "Field Test for Moisture Equivalent" described in detail in the report gives a tentative criterion for classifying soils as to their suitability for use as a subgrade.

The addition of 5 per cent. of hydrated lime or Portland cement to a soil materially reduced the expansion and contraction of the soil. The admixture of sand with the soil has a similar effect.

Heat treatment of the soil requires a temperature of 600° C. to effect a physical change in the soil. At this temperature the clay content is reduced and the sand content increased, resulting in a reduction of the expansion and contraction of the soil.

Drainage ditches are effective only in removing water in excess of the capillary moisture.

There is every evidence to show that temperature has a very marked influence on the water capacity of soils. The colder the soils the greater the capacity for holding moisture.

Some materials, such as many types of clays, take up considerable quantities of moisture when it is available and expand in volume, while other materials like sand, gravel, crushed slag, etc., take up only enough moisture to coat the surfaces of the particles and show little expansion.

When macadam or broken stone bases are used over a heavy clay subgrade it often happens that the clay is forced up through the voids in the stone and renders the broken stone layer much less resistant to loads. A light blanket of sand or similar material interposed between the subgrade and the broken stone is effective in preventing the clay from working up through the overlying stone layer.

The soil itself does not expand on freezing, but the expansion occurs in the moisture alone.

2. Sand-Clay, Top Soil and Semi-Gravel Roads

For successful roads there is required:

(a) Graded mixtures capable of making a dense mass on consolidation. The best mixes run as low as 20 per cent porosity.

(b) Uniformity of composition secured by thorough mixing.

(c) Heavy compacting from the bottom upward. This is usually done by traffic. There is need for a type of multiple rim roller to hasten and unify the degree of compactness imparted to these roads during construction.

(d) The mixtures must have a liberal amount of coarse material above No. 60 sieve.

(e) Depth of compacted surface should be 10-12 inches. Crown of ¼ inch per foot is sufficient.

3. Forces on Pavements Resulting from Traffic

Preliminary tests of the Bureau of Public Roads indicate that, when driving over a typical concrete road at high speed with a fully loaded 2-ton truck, we may expect impact values of approximately 20,000 pounds, or over five times the static load on one rear wheel. With a fully loaded 5-ton truck at high speed we may expect forces of 35,000 to 40,000 pounds, or over four times the static load on one rear wheel. If a downward movement of the loaded truck body occurs at the same instant as an impact the two forces are of course additive, and the result may be double the impact. Therefore, under certain bad surface conditions a total force of 40,000 to 50,000 pounds may be obtained at each rear truck wheel.

The semi-monolithic brick pavements showed less resistance to impact than the monolithic brick pavements with same depth of concrete base (Bates Road). The monolithic brick pavements showed about 12 per cent less resistance to impact than the plain concrete slab of equal depth. These results obtained by the Bureau of Public Roads on slabs 7 feet square.

The observed deflections of concrete pavements are very nearly directly proportional to the load (Pittsburgh Test Road).

The resistance to structural failure of plain concrete pavement slabs of uniform thickness and laid on a uniform subgrade, when subjected to highway traffic loads, is in proportion to the square of the thickness of the slab (Bates Road Test).

Structural failure normally first appears at corners caused by open cracks or joints. The edges of ordinary pavement slabs should be strengthened so that the corners and the edge of pavement may have approximately the same resistance to structural failure as the interior portion of slab.

The endurance limit of concrete when subjected to repeated tensile stresses may safely be taken as not less than 50 per cent. of the modulus of rupture of the material (Bates Road Test).

Interesting Road Work in North Carolina

Building an embankment across a marsh on a corduroy base. Founding a bridge abutment on a quicksand bottom.

Highway work in North Carolina is interesting not only because of its magnitude, but also because of many unusual methods of solving problems presented. An illustration is furnished by Project 131 in Gates county. The work consisted of grading a road bed 30 ft. wide and topsoiling 10 in. deep and 18 ft. wide.

About 6,000 ft. at one end crosses a cypress marsh that is more than usually swampy because of continual overflow from the Chowan river. A person can stand on a stump beside the road and push a pole or sapling ten feet or more into the marsh with only the weight of his body. The right-of-way is being cleared 90 feet wide and before embankment is started the entire distance between slope stakes is conduroyed with logs having a minimum diameter of 8 inches, making a solid mat of logs for the four-foot embankment to rest on. At the time of writing about one-third of the embankment had been completed and very little settlement has taken place. The highway here follows an old road built over one hundred years ago and during that time has been corduroyed at least twice and built up on several occasions, and it is believed that there is a good foundation for the present highway. The 27,000 cu. yds. of earth for the embankment is being secured from two borrow pits on comparatively high ground just outside the marsh and is brought over a narrow-gauge track of 20-pound rails in six 2-yard Western side-dump cars drawn by a Plymouth gasoline dinkey engine.

In Project 132 in this county perhaps the most interesting feature is the construction of the footing of a bridge abutment. The excavation for this was carried about six feet below the level of the surrounding swamp and after driving wooden sheet piling this was done with comparative ease. Bearing piles were then driven with a penetration of about 24 feet and these seemed to loosen a bed of quicksand and when about a month later the cofferdam was pumped out to permit putting in a concrete footing, the bottom of the sheet piling caved in. This was the beginning of no end of trouble, the only solution of which seemed to be to drive new sheet piling. This was done and a 4-in. seal course of concrete was laid to shut out the numerous and vigorous sand boils. Because of these, which raised the bottom about a foot with quicksand while the excavation was filling with water, the usual method of depositing the concrete under water by tremie was impracticable. Instead, the excavation was kept pumped out and, beginning at one end of the cofferdam, the excavation was carried 4 inches below the bottom of the footing across the cofferdam and for a width of about 4 feet, covered with a layer of roofing paper, and four inches of concrete immediately placed on this. This was repeated until the entire bottom had been covered, and the abutment then built successfully.

Project 133 is the first highway ever built across the famous Dismal Swamp. The roadway is being built by C. W. Lacy, of Wilmington, N. C., and the structures by the Pittsburgh Des Moines Steel Co. of Pittsburgh, Pa. The swamp here is four miles wide and a remarkable feature of it is that there is not at any point in the four miles the slightest indication of any flow of water, even after heavy rains when the water in places may be two feet deep, and in spite of the fact that there is always less standing water here than anywhere else in the swamp. It is also remarkable that the entire swamp is higher than the cultivated fields east of it and drains into them. The right-of-way is being cleared 125 feet wide, to allow for a 30-foot roadway and a 24-foot canal on one side of the road; the canal serving the double purpose of draining the road and furnishing material for the embankment, which is being built to an average height of four feet. The top two feet of excavation is found unsuitable for embankment but the material below that is unsuitable. On the other side of the road a small ditch is run and at intervals of two thousand feet reinforced concrete pipe culverts under the embankment drain it into the canal. The excavation and embankment are being made with two P. & H. drag lines, one with a ¾-yard bucket and the other with a 1½-yard bucket.

The roads above referred to will connect with the rest of the state six counties that are cut off from it by an unbridged river and three of them by the Dismal Swamp in addition. P. Y. K. Howat is resident manager on the work described above.

Coarse Binder in Philadelphia

The city of Philadelphia has laid an experimental section of asphalt pavement, the details of construction of which were unusual in that city's practice and probably have not been tried out in exactly this combination anywhere else. The object was to find a method of reducing the tendency of asphalt pavements to shove or creep.

In August, 1922, specifications were prepared for repaving 22d street, from Spruce to Fitzwater, with sheet asphalt, with granite blocks laid between the street railway tracks. Between South and Fitzwater the pavement consists of the standard 1½-inch binder and 1½-inch surface course on a 6-inch concrete foundation. Between South and Spruce streets, however, a pavement was laid that possesses three principal points of difference from the stand-

ard practice, these being in the base, the composition of the binder course and the thickness and composition of the surface course.

The surface of the concrete base was roughened so as to prevent motion of the binder course, this being effected by imbedding 1½-inch slag or stone in the surface, these stones projecting from ¾ of an inch to 1¼ inches above the surface and spaced about 1½ to 2 inches apart. The stone used in the binder course was increased from ¾-inch to 1½-inch size, well graded but with a majority of the larger stones. This naturally necessitated increasing the thickness of the binder course from the usual inch or 1½ inches to 2 inches. The surface mixture was reduced in thickness from 1½ inches to 1-inch and there was mixed with it about 25% of clean trap rock chips.

The object, as stated, was to construct a pavement the surface of which would not creep under heavy one-way traffic. Whether this construction will be successful in securing this cannot yet be told, as the work was not completed until October of 1922.

Some difficulties were encountered in developing this construction. The most difficult feature was giving the desired roughness to the concrete surface. On the east side of the street slag aggregate was used in the concrete and crushed slag spread over the surface a few minutes after the concrete had been deposited. The imbedding of the slag in the slag concrete was found to be difficult, pieces which appeared to be thoroughly imbedded being found resting loose on top after the concrete had set up. In an effort to overcome this, the concrete was mixed somewhat wetter than customary, but even so it was difficult to determine, while the concrete was wet, whether the slag on the surface would be found well imbedded after the concrete had set.

On the west side of the street the concrete was made with a pebbled aggregate instead of slag and it was found that with the rounded pebbles the slag on the surface imbedded itself much more readily and uniformly.

Determining just the proper proportions of asphalt, sand, and small and large stones to provide a binder course that would give a well-filled surface, but in which the large stone would predominate, required considerable experimenting. Starting with a mixture containing 20% of sand by weight, it was found necessary to reduce this to 15%, and while at first a mixture of 1½-inch to ¾-inch slag was used, it was found necessary to use practically uniform 1½-inch material in order to avoid an excess of small size. A mixture was finally decided upon which gave a close binder with all of the pieces well coated and just enough roughness of the surface to provide a binding with the surface mixture. This binder was much more difficult to work on the street than that made of ¾-inch aggregate, requiring considerably more pressure on the rakes, and because of the larger aggregate and greater thickness it was necessary to continue the rolling of this course longer than with the standard binder.

The surface mixture used consisted of 7.5% bitumen, 25% stone chips, 9% limestone dust and the balance sand. This mixture could be raked easily and worked into an excellent surface.

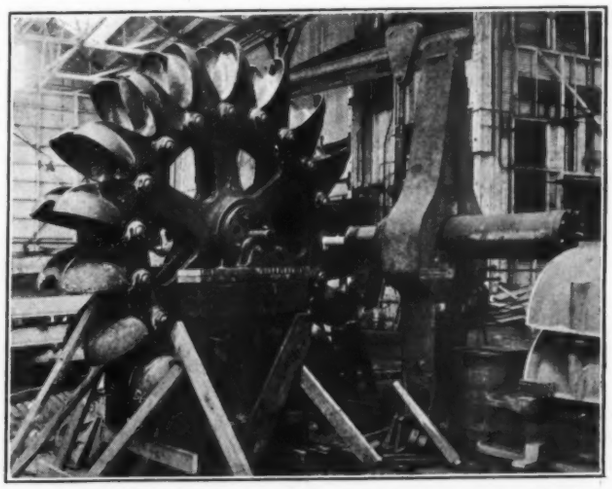
The Moccasin Creek Power Plant

By Charles W. Geiger

The generation of hydroelectric power is an important feature of the Hetch-Hetchy project of San Francisco. A number of power houses are provided for in the ultimate plans which will not be built at present. Storage of water cannot be provided at any of the future plants, and that located at Moccasin creek has been designed to act as a regulating plant for the entire system, the other plants operating on a unity load factor. To provide storage at Moccasin creek, a dam was built across it consisting of a concrete corewall extending to bed rock, a rock-filled down-stream toe and a similar up-stream toe with riprap paving, with hydraulic fill adjacent to the corewall. The reservoir so created will have a capacity of 2,500 acre-feet, or two days' flow of the aqueduct at maximum capacity. Water for the power house passes directly to the penstocks through a tunnel 590 feet long and with a capacity of 1,240 second-feet.

From this tunnel to the power house, measured along the slope, is 4,910 feet. The first 1,255 feet has a moderate slope and here four penstocks are used, two for each group of three units ultimately to be installed in the power house. Each penstock has a capacity of 310 second-feet and a diameter decreasing from 92 inches to 86 inches providing for increased velocity. The remaining 3,655 feet is considerably steeper and here there is a penstock for each unit, the diameters tapering from 72 inches to 56 inches at the power house, where there is a Y connection between each penstock and two 36-inch pipes leading to 36-inch gate valves controlling the supply to each runner.

The power house is 300 feet long, 50 feet wide and 50 feet high, with plain walls pierced at regular intervals with tall, narrow windows. An arcade along one side is built over the grating



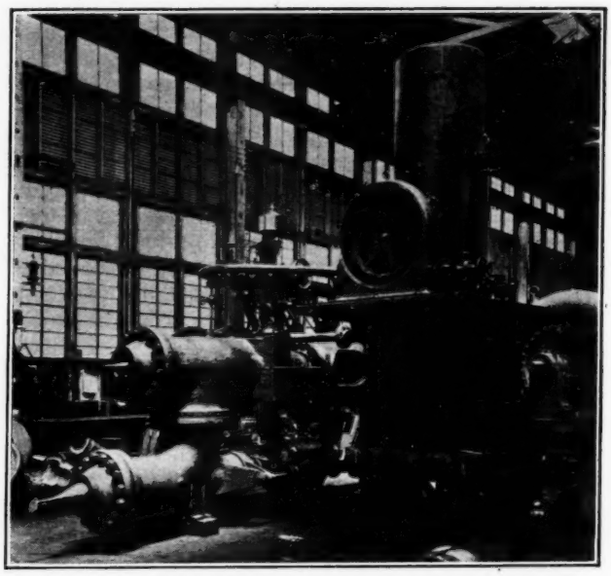
FORCING BOLTS INTO PLACE IN IMPULSE WHEEL BY MEANS OF HYDRAULIC CYLINDER.

through which air will be drawn to cool the generators, and another arcade along the other side shelters the valves controlling the turbines. The interior of the building is one large room with a narrow gallery.

The plant is designed to accommodate six 25,000 h. p. units, but only four will be installed at the present. Each unit consists of a Pelton double overhung horizontal impulse turbine direct connected to a 20,000 K. V. A. 11,000 volt General Electric generator. The exciters will be direct connected to the main generators, being mounted on a stub-shaft equipped with a forged flange, which is bolted on an extension of the main shaft. Each main generator will be mounted between two main bearings, a water wheel runner being overhung on each end on the extended shaft. This turbine will be under a static head of 1,315 feet and an average effective head of 1,250 feet.

The runners are of the chain type, each comprising an annealed cast steel hub, two forged steel disks and the requisite number of ellipsoidal buckets. Each bucket has three lugs, the middle one fitting into the recess between the two disks and the outer lugs fitting on the outside of the disks. Each bolt passes through the two rear or outer lugs of one bucket and the middle or forward lug of the bucket immediately following. All bolts are pressed into reamed holes in order to secure absolute accuracy in fitting. The peripheral velocity of the runners is about 100 miles per hour.

Water is delivered to each runner by a needle nozzle equipped with an auxiliary relief needle nozzle, the function of the latter being to permit accurate regulation of speed and pressure with maximum water economy. When the load decreases, causing the governor to reduce the opening of the power nozzle, the relief nozzle is opened coincidently and for an instant discharges water at the same rate that the power nozzle reduces its flow and the relief nozzle then closes slowly, the rate of closure being adjustable so as to secure any desired limitation of pressure rise in the penstock. It is said that for the most severe conditions of operation this rise can be limited to 15 per cent. When the load reductions are too small to produce objectionable pressure the relief nozzle does not open at all. Braking nozzles are provided for each runner, which open automatically whenever the water is shut off the wheel and bringing the wheel to rest from full speed in 7 minutes or less. The stream from the relief nozzle discharges against a baffle which turns the jet upon itself and destroys its energy.

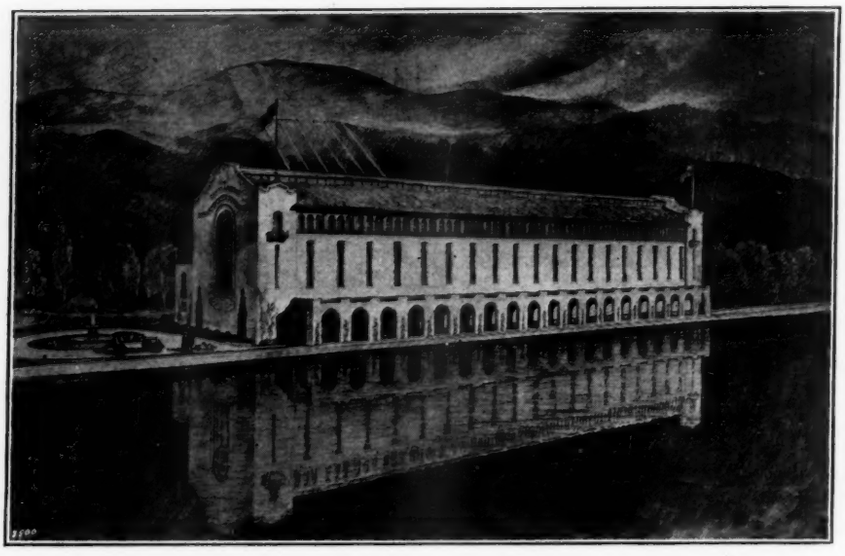


RELIEF NEEDLE NOZZLE, DIRECT-MOTION GOVERNOR, AND OIL PUMPING SYSTEM FOR FURNISHING PRESSURE OIL TO GOVERNOR.

Latin-Americans to Inspect Highway

The Highway Education Board of the Pan-American Highway Commission is to conduct forty Latin Americans with broad experience in highway affairs on a trip of three weeks early next summer over highways of the United States. This trip was suggested by a Pan-American motor highway conference sanctioned at the Fifth International Conference of American States held at Santiago, Chile, last year. Officials of several United States government departments are co-operating, including Secretaries Hoover and Work and Thomas H. MacDonald. The trip will be in charge of S. T. Henry.

Mr. MacDonald is to plan the itinerary, giving special consideration to the climatic, soil, topographic, population and financial conditions of the several countries represented by the delegates.



MOCCASIN CREEK POWER HOUSE, HETCH-HETCHY WATER SUPPLY.

Recent Legal Decisions

CONTRACT FOR HAULING STONE

Under a contract for hauling stone to be used by a contractor for the construction of a highway, it was the duty of the subcontractor to roll the stone after it was placed on the surface. In an action by the subcontractor for stone hauled and for damages for breach of contract, the Arkansas Supreme Court holds, Parker v. Stephens, 247 S. W. 393, that he was not concluded by monthly settlements based on the road district engineer's estimates which included only stone rolled and placed on the road and did not include stone hauled but not placed.

ROAD CONTRACTORS PAID IN ORDER OF EXECUTION OF CONTRACTS

The Texas Court of Civil Appeals, Austin Bros. Bridge Co. v. Road Dist. No. 3 of Liberty County, 247 S. W. 674, holds that the creditors of a road district must be paid from its funds in the order of the execution of the contracts under which they arise. "When one makes a contract with a commissioners' court for the performance of work on the roads of a road district, he at once acquires a vested interest in the funds of such district to the full extent of his contract, and the commissioners' court has no power to impair such vested right by paying out the funds to subsequent contractors or creditors. The rights of all subsequent contractors are inferior to the first contractor. Their claims against the funds of the district must be determined in the order of their contracts. First National Bank v. Terry, Briggs & Co., 203 Ala. 401, 83 So. 170."

INJURIES ON STREETS—RECORD ACCEPTANCE FOR WORK DONE

Contrary to the decisions in some jurisdictions, the Supreme Court of Appeals of West Virginia holds, Zirkle v. City of Elkins, 115 S. E. 875, that under the statutes of that state acceptance by direct municipal action or by work done thereon by the municipal authorities of a part of the streets and alleys of an addition will not amount to an acceptance of all of such streets and alleys, but only such of them as by record action or by work done thereon by the municipal authorities are shown to have been accepted; that mere use thereof by the public or even by the municipal authorities will not amount to such acceptance. Without such acceptance or work done thereon, the municipality will not be liable for injuries sustained in the street or alley; mere dedication to the public would not be sufficient.

COUNTY BOARD HELD NOT ENTITLED TO CANCEL HIGHWAY IMPROVEMENT CONTRACT

A highway contractor entered into a contract with a county board of commissioners for the improvement of a highway, under which he expended money preparing to proceed with the improvement as soon as the county treasurer should realize money from the sale of bonds. The commissioners, however, decided to order the cancellation of the contract, desiring to contract for another kind of road, and sued to have the contract set aside. The contractor sought to enjoin the commissioners from canceling the contract. The Indiana Appellate Court held, Buck v. Indiana Const. Co., 138 N. E. 356, that the contractor was entitled to the injunction sought, since the commissioners had no power to cancel or set aside the contract, and that the plaintiff "had no adequate legal remedy as practical and efficient to the ends of justice and its proper administration as the remedy in equity."

BOARD MAY OMIT FROM ORDER FOR IMPROVEMENT PART OF ROAD PETITIONED FOR ALREADY IMPROVED

Where it appears that part of the road described in the petition for a road improvement, which was not ordered improved by the county board of commissioners had been theretofore sufficiently improved so as to conform with the proposed work, the board may omit that part from its order and direct the balance of the work improved. Cole v. Board of Comrs. of Noble County (Ind. App.), 138 N. E. 859.

TIME FOR INTERVENTION IN SUIT ON PUBLIC WORKS CONTRACTOR'S BOND

The Federal District Court for the Eastern District of New York holds, United States v. Rangely Const. Co., 288 Fed. 76, that another claimant may not intervene in a suit by a subcontractor on the bond of the principal contractor under the Act of Aug. 13, 1894, for the protection of those furnishing materials and labor for public works, as amended in 1905, after the expiration of the year fixed by the statute; and the time for intervention is not extended by previous commencement of suit in a state court.

FREE SERVICE TO CITY

To an objection that an electrical company, the Midwest Power Company, furnished the city of Enderlin free light for the city hall, it appeared that this was provided for in the franchise as a consideration for the use of the streets and alleys. The amount of electricity so used was small, and the North Dakota Commission held that it could not be properly called discriminatory "free service."

OWNER CONNECTING WITH SEWER CANNOT ATTACK TAX BILL FOR ITS CONSTRUCTION

The Supreme Court of the United States holds, St. Louis Malleable Casting Co. v. Geo. C. Prendergast Const. Co., 43 Sup. Ct. 178, that a property owner who, during the construction of a sewer in his district, makes application for a license to connect with it, and afterwards does connect with it, cannot thereafter attack the validity of a tax bill issued to pay for the construction of the sewer.

CITY HELD LIABLE FOR MISTAKE IN MARKING BOUNDARY LINES

The Georgia Court of Appeals holds, Savannah v. Spalding Const. Co., 116 S. E. 346, that a municipal corporation, when undertaking for a consideration through its city engineer or surveyor, under authority of an ordinance of the city, to measure and mark out land lines between adjoining property owners, is not engaged in a governmental function, but in a ministerial function involving no governmental duties, and is therefore liable to one with whom it has contracted to perform such duty for damages arising from a failure to properly perform such duty. Where the city by mistake runs the land lines so that the lot marked off as belonging to the owner would include land to which he had no title, and the owner erects on the lot so marked off a house which encroaches upon land to which he has no title, he may recover for damage sustained by him in so building his house as a result of the mistake made by the defendant. The damage sustained by the plaintiff was held to be the cost of removing the house and replacing it on his own lot, as determined by the true measurements.

CONTRACT PROVIDING FOR COMPLETION WITHIN REASONABLE TIME

A contract to dig 100 miles of trenches and lay tile therein with the work incidental thereto, fixed no definite time for completion, merely stipulating that the work "be prosecuted vigorously and continuously." The Circuit Court of Appeals, Eighth Circuit, holds, Roswell Drainage Dist. v. Dickey, 292 Fed. 29, that the contractor was only bound to complete the work in a reasonable time, the existing conditions, situation and circumstances regarded; and where the work was being prosecuted before, during, and after the country entered the Great War, reasonable time must be determined with reference to the scarcity of labor, incompetency of laborers secured, and difficulties in procuring materials and repairing machinery which prevailed. In any event, insistence on the contractor proceeding to complete the work, after his alleged breach of contract by delay, while payments to him were in arrears, was held a waiver of such delay.

GASOLINE SUPPLY PUMPS ON STREETS AN UNLAWFUL OBSTRUCTION

The New York Appellate Division, in Hardin v. New York Central, 205 App. Div. 157, 199 N. Y. Supp. 550, holds that, while hitching posts, stepping stones, watering troughs, and things of that kind, being for a public use, are not, of themselves, unlawful obstructions in the streets, and awnings, if they may be authorized by the city authorities, though they may be encroachments, are of too unsubstantial a nature to be seriously considered as public nuisances, the obstruction of a gasoline supply pump, located within the street lines close to the curb stone is not insignificant, is not a public use, and is unlawful, not only in the structure itself, but in the lines of vehicles frequently and sometimes almost continuously waiting for service. The Buffalo City Charter does not authorize the city to grant a license for the erection of such pumps on city streets so as to constitute an obstruction and nuisance.

OVERHANGING EAVES PREVENTING PRESCRIPTION AS HIGHWAY

The New Hampshire Supreme Court holds, Woodsville Fire Dist. v. Stahl, 119 Atl. 123, that a town cannot acquire by use a prescriptive right to that part of a sidewalk under the eaves of a building. A legal highway including not only the soil but also all the space above it, (State v. Kenn, 96 N. H. 122), such an occupany by the owner was a continuous assertion of a right inconsistent with the public right.

OVERFLOW FROM MUNICIPAL SEWAGE DISPOSAL PLANT

In an action to enjoin a municipality from permitting the overflow of its sewage disposal tanks on plaintiff's lands during the rainy season or on the happening of heavy rains, the Circuit Court of Appeals, Fifth Circuit, City of Amarillo v. Ford, 288 Fed. 162, held that the city should be permitted to acquire by condemnation such portion of the plaintiff's land as is needed to handle the overflow of water from its sewage plant, at an assessed value. For the flow of storm waters which would occur on plaintiff's land were there no sewerage, the city would not be liable.

SPECIAL INJURY MUST BE SHOWN BY PROPERTY OWNER TO RESIST VACATION OF STREET

The Circuit Court of Appeals, Ninth Circuit, holds, Lockwood v. City of Portland, 288 Fed. 480, that a lot owner cannot resist the vacation of a street under competent authority, or recover damages for such vacation, unless he shows a legal injury to his property, different in kind, and not merely in degree, from the injury suffered by the public at large. A property owner whose property is surrounded by four public streets has no standing in a court of equity to enjoin vacation of one of the streets by municipal authorities, or in a court of law to recover damages for such vacation. The lot owner may have occasion to use the street oftener than others, because of its proximity to his property, and for that reason his inconvenience may be greater than that of others; but all the authorities agree that this is a difference in degree, and not in kind.

STATE MAY AUTHORIZE CITY TO REQUIRE VIADUCTS OVER RAILWAY TRACKS AT STREET CROSSINGS

The North Carolina Supreme Court holds, City of Durham v. Southern R. Co., 117 S. E. 17, that the state in the exercise of the police power may authorize a city to require a railroad company to construct at its own expense such viaducts over its tracks at street crossings as may be necessary for the safety and protection of the public.